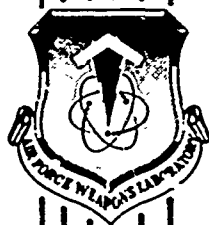


CALCULATIONS OF ENERGY LOSS, RANGE,  
PATHLENGTH, STRAGGLING, MULTIPLE  
SCATTERING, AND THE PROBABILITY  
OF INELASTIC NUCLEAR COLLISIONS  
FOR 0.1-TO 1000-MEV PROTONS

Joseph F. Janni

1Lt USAF



TECHNICAL REPORT NO. AFWL-TR-65-150

September 1966

AIR FORCE WEAPONS LABORATORY  
Research and Technology Division  
Air Force Systems Command  
Kirtland Air Force Base,  
New Mexico

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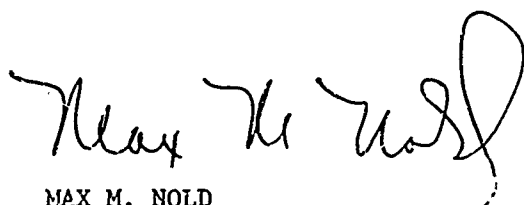
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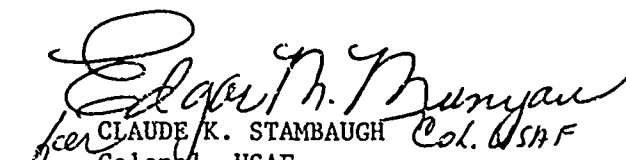
This research was performed under Program Element 61.44.50.14, Project 8803. Inclusive dates of research were 1 September 1964 to 1 May 1966. The report was submitted 27 May 1966 by the Air Force Weapons Laboratory Project Officer, Lt Joseph F. Janni (WLRB).

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This technical report has been reviewed and is approved.

  
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## ABSTRACT

Theoretical calculations have been made of the mean energy loss, pathlength, range, multiple scattering, and pathlength straggling of protons in 74 materials, including materials regularly used in radiation shielding and dosimetry. Emphasis has been placed on obtaining accurate results, especially for heavy materials and protons of very low energy. Values of the energy loss between 0.1 and 1.0 Mev were obtained by smoothing and interpolating experimental information. Above 1.0 Mev, the Bethe equation with all the necessary shell corrections has been used. The polarization effect has been calculated in detail for each material. Ranges have been obtained from the pathlengths by use of detailed multiple coulomb scattering theory. Comprehensive tabulations of the range straggling and multiple scattering have been presented for each of the materials. The energy loss and range calculations have been compared with the available experimental data and the mean deviation is usually within 1.0 percent. Deviation rarely exceeds the estimated error of the experimental data. The theoretical approach is also discussed in detail, and the method used to obtain the K, L, M, N, and O shell corrections is presented. A first-order correction has been made which compensates for the molecular binding effects occurring in compounds. The probability that a proton will undergo an inelastic nuclear interaction throughout its entire pathlength is also tabulated.

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## SECTION I

### INTRODUCTION

The energy loss, range, pathlength, pathlength straggling, and multiple scattering of protons in absorbing media are of considerable importance to many research groups. In the past, the demand for such information has been generally limited to the practical requirements of nuclear physics research; however, the parameters which govern the energy loss mechanism are now being studied with interest by shielding groups, geophysicists, and biophysicists.

The express purpose of this report is to provide an accurate set of tables which contain the significant parameters pertinent to the interaction of protons with matter. These tabulations have been provided for a large number of materials in an energy grid which is fine enough to permit simple linear interpolation in obtaining intermediate numbers with no loss of accuracy in the significant figures.

Although proton pathlength and energy loss have been presented in several other reports (References 1 through 10), no comprehensive set of calculations has been published which considers energy loss, pathlength, range, straggling, multiple scattering, and the probability of an inelastic nuclear interaction.

The results of such calculations have many practical uses. It is common practice at many proton accelerator facilities to rely upon tables such as these for values of the proton range and energy loss. The beam energy is frequently estimated by measuring the particle transmission through a known thickness of degrader. When this is done, reliable values of the multiple scattering are essential to the accuracy of the results. This information has not been previously available over a wide energy range for a sufficient number of materials.

The interest of the biophysicist in protons is a result of the large amount of energy transferred by such protons to an absorbing medium composed of living cells. Low energy protons transfer much more energy per unit pathlength than do protons of high energies. Biological experiments indicate that a rapid increase in the energy transferred results in a sharp increase in the cell lethality. In addition, the recovery probability of living cells appears to be



directly related to the energy transferred per unit pathlength by the incident radiation. Exploration of the energy loss of protons is therefore of biological significance, and requires that the energy loss of a proton traversing an absorbing medium be known accurately.

The interest of the geophysicist engaged in space radiation research is akin to that of the shielding groups. Many organizations involved in manned or unmanned spaceflight, as well as those involved in reactor and accelerator technology, have developed computer codes which are capable of solving shielding problems by using radiation transport techniques. The primary proton penetration and energy loss are usually obtained from tables within these codes. The input data for these tables usually are obtained from the literature, such as those in references 1 through 9.

It appears that there have been some misuse of these data, since all but one of the above references provide the pathlength, not the range. The shielding problem usually requires the range, and not the pathlength. These terms appear to have been used almost interchangeably in the past. The pathlength and range should not be considered identical, as they differ in some cases by several percent. It should be emphasized that the straggling and multiple scattering of protons are not negligible if accurate results are required.

Since the terminology used in this report is somewhat different from that suggested by Fano in a recent review (Ref. 11), it is felt that some preliminary definition of terms is called for here, even though all of the important quantities will be mathematically defined in later sections. The terminology of reference 11 is indicated in parentheses whenever a difference exists.

PATHLENGTH (Continuous Slowing Down Approximation Range, CSDA) is the total mean distance traveled by protons from the point at which they enter the material with a definite kinetic energy to the point at which this energy is nearly zero and no additional displacements are observed. Protons which undergo inelastic nuclear interactions suffer abrupt energy losses; this definition does not apply to them.

RANGE (Projected Range) is the mean depth of penetration measured along a straight line from the point at which the protons enter an absorbing medium to the point at which additional displacement is no longer detectable. The range is always less than the pathlength by a small but finite amount. This is a result of the multiple scattering process, which has been calculated in detail for all energies and each material.

PATHLENGTH STRAGGLING is primarily the result of the statistical process involved in the proton energy loss mechanism. Protons lose kinetic energy in small discrete amounts as they undergo a multitude of collisions with atomic electrons. Thus, an initially monoenergetic beam of protons will have an energy spread after passing through a finite thickness of absorber. This causes a small but definite straggling to exist about the mean total pathlength. This straggling has been graphically demonstrated with the pathlength and range in figure 1.

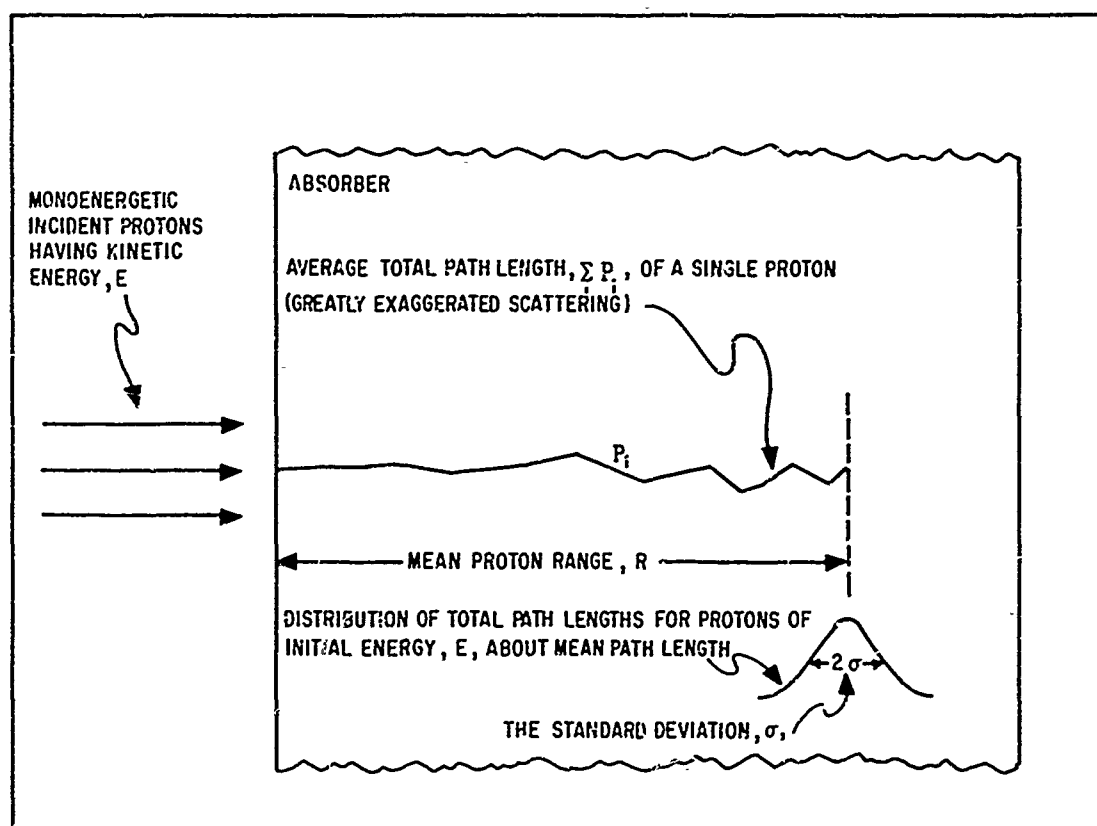


Figure 1. Illustration of the Relationship Between Average Pathlength, Mean Range, and Pathlength Straggling

MEAN EXCITATION ENERGY is the mean value of all the excitation and ionization potentials of the atom, and represents the average least energy that can be transferred to an atomically bound electron. This quantity can be rigorously defined in terms of the atomic absorption frequencies,  $E_i/h$ , and the oscillator strengths,  $f_i$ , by:  $I = \exp[\sum_i f_i \ln E_i]$  (Ref. 11). In principle, this could be done for all elements; in practice such calculations have been carried out for only a few of the simplest cases. The numerical value of the mean excitation

energy must be defined in association with stopping power corrections for the nonparticipation of inner shell electrons which remain finite in the extreme relativistic limit.

ADJUSTED IONIZATION POTENTIAL (Adjusted Mean Excitation Energy) is related directly to the mean excitation energy, and is the "ionization potential" which is most frequently used in conjunction with charged-particle energy-loss equations. It is usually determined experimentally assuming that all corrections to the stopping power equation for the nonparticipation of the inner shell electrons are negligible at very high proton energies and that they are zero in the extreme relativistic limit. Although Fano and Turner (Ref. 12) have shown that the shell corrections do not actually vanish even at the highest energies, the assumption of vanishing shell corrections does yield accurate results if the adjusted ionization potentials are chosen with this assumption in mind.

Derivations of the equations which have been used are not presented or discussed in detail here, since these relationships are well known and may be found in the references.

## SECTION II

### ENERGY LOSS CALCULATIONS

#### 1. Proton Energy Loss

Protons traversing matter may lose energy by any or all of the following interactions:

a. Excitation and ionization of the atoms and molecules of the absorbing material are the dominant mode of loss by moderate- and low-energy protons.

b. Inelastic nuclear collisions become quite significant at high proton energies and contribute heavily to the total energy loss.

c. Elastic interactions occur with atoms in which the incident proton transfers kinetic energy to the recoil nuclei.

d. Photon emission in atomic fields because of particle deceleration is the least important of the proton energy-loss processes. This interaction is commonly called bremsstrahlung.

The proton energy loss by ionization and excitation has been calculated using the well-known Bethe equation (Ref. 10), and has been corrected for the effects of nonparticipating inner shell electrons. The probability that a proton will undergo an inelastic nuclear interaction throughout the entire stopping process has been tabulated to estimate the significance of these collisions.

The contribution of elastic nuclear collisions to the total energy loss is less than one tenth of 1 percent at 0.1 Mev, and is even less significant at higher kinetic energies. For this reason such elastic collisions have not been considered.

When it is compared with the ionization and excitation energy loss, proton bremsstrahlung is completely negligible at the energies considered here and has not been included in the calculations. For example, emission of virtual photons and bremsstrahlung is only a fraction of 1 percent of the total energy loss for 10 Bev protons, drops sharply at lower energies, and is insignificant at the minimum ionization energy (Ref. 13). The minimum ionization energy is near 2 Bev and is the highest energy considered in this report.

#### 2. The Bethe Equation

The Equation for the energy loss from atomic ionization and excitation is

$$\frac{1}{\rho} \frac{dE}{dX} = \frac{2\pi N_o z^2 e^4}{mc^2 \beta^2} \frac{Z}{A} \left[ \ln \frac{2mc^2 \beta^2 W}{I_{adj}^2 (1-\beta^2)} - 2\beta^2 - 2 \frac{\Sigma_i C_i}{Z} - \Delta \right] \quad (1)$$

where

W is the maximum kinetic energy which can be transferred to an electron which is initially at rest.

$\rho$  = density of the material.

z = effective charge of proton (unity above 0.5 Mev).

c = velocity of light in a vacuum.

e = electronic charge in esu.

m = rest mass of the electron.

A = the atomic weight of the stopping material

$N_o$  = Avogadro's Number.

Z = atomic number of the stopping material.

$I_{adj}$  = the adjusted ionization potential.

$\beta$  = ratio of the incident particle velocity to the velocity of light; v/c.

$\Sigma_i C_i$  = the sum of the effects of shell corrections on stopping power.

$\Delta$  = the polarization effect correction term.

The maximum energy transfer W can be expressed as a function of proton energy or as a function of the particle velocity. In the interest of consistency, however, only the latter has been used:

$$W = \frac{2mc^2 \beta^2}{1 - \beta^2} \left[ 1 + \frac{2m}{M\sqrt{1-\beta^2}} + \left( \frac{m}{M} \right)^2 \right]^{-1} \quad (2)$$

where M is the proton rest mass.

When equations (1) and (2) are combined, the result is

$$\frac{1}{\rho} \frac{dE}{dX} = \frac{4\pi N_o z^2 e^4}{mc^2 \beta^2} \frac{Z}{A} \left\{ \ln \frac{2mc^2 \beta^2}{[I_{adj}(1-\beta^2)] \sqrt{1 + \frac{2m}{M\sqrt{1-\beta^2}} + \left( \frac{m}{M} \right)^2}} - \beta^2 - \frac{\Sigma_i C_i}{Z} - \frac{\Delta}{2} \right\} \quad (3)$$

The form of this equation published by Livingston and Bethe in 1937 (Ref. 10) neglects the small effects of the square root term within the logarithm. This term is quite close to unity except at very high energies. For example, omission of the term increases the energy loss at 1000 Mev by only 0.017 percent in aluminum. Nevertheless, it has been included in the calculations.

In order that the derivation which results in equation (1) be valid, the energy transferred to an atomic electron must in general be greater than the binding energy of that electron in its atomic shell. This condition can be partially removed by appropriate use of the shell corrections described in a later section. The incident proton must also be represented accurately by a point charge and a point mass. This is the case for all the energies presently under consideration. Although it is not a rigorous requirement, another useful indication of the low-energy validity of equation (3) is the numerical value of the logarithmic term, which should generally be greater than zero. This requires that the kinetic energy of the proton be

$$E > \frac{M}{m} \frac{I_{adj}}{4} \quad (4)$$

where M is the rest mass of the proton. This condition is always satisfied for 1.0 Mev protons.

### 3. The Polarization Effect

The perturbation of the field of the passing proton which is caused by the electric polarization of the surrounding atoms results in a reduction of the energy lost by the charged particle. This effect has been discussed in detail by several authors (Refs. 14 through 18). The energy loss is usually reduced by less than a percent at the energies calculated in this report. At 1000 Mev the stopping power is reduced by 0.8 percent in beryllium, 0.5 percent in copper, and is insignificant for very low density materials, such as gases, at standard temperatures and pressures. For elements having higher atomic numbers the medium is less strongly polarized because most of the atomic electrons are more tightly bound.

Although approximate corrections are available for a number of materials in references 16 and 17, the polarization correction has been calculated here for each material using the fundamental equations of the theoretical model proposed by Sternheimer in the aforementioned references. This correction has

been applied to all of the materials tabulated in this report. The result obtained for aluminum is compared to that of Sternheimer and the calculation of Hill et al. in figure 2.

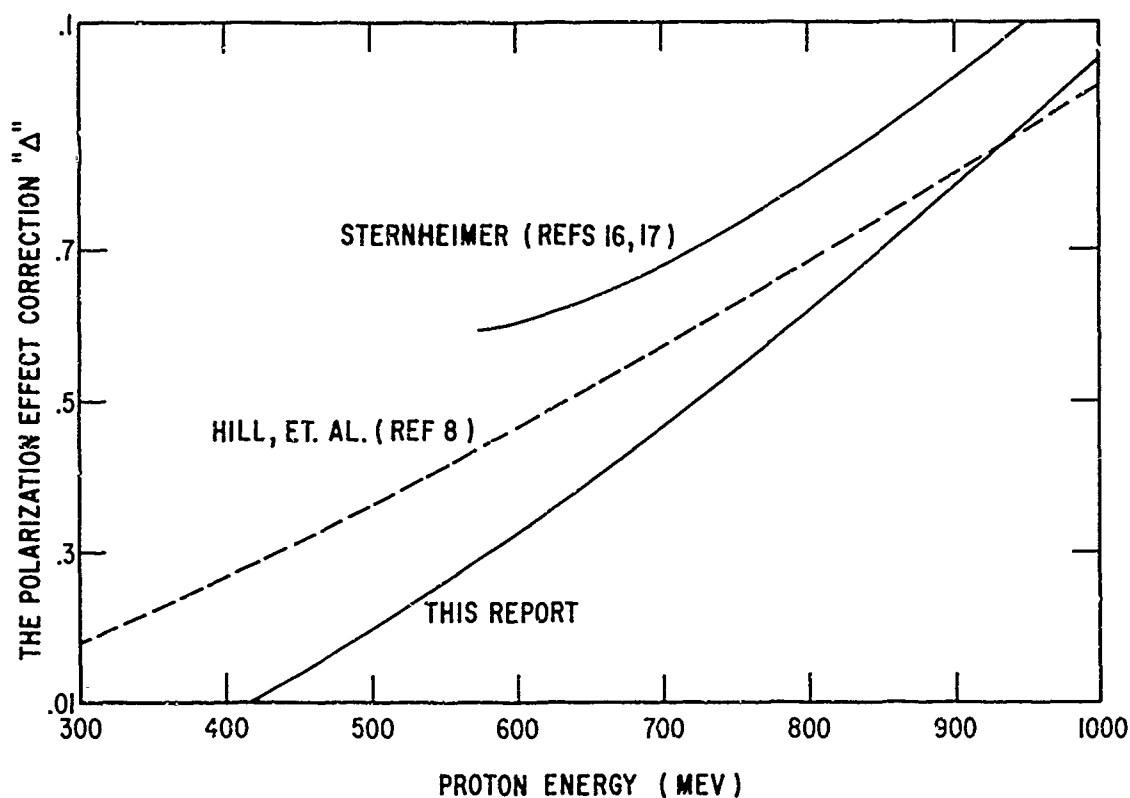


Figure 2. A Comparison of the Polarization Effect Corrections Calculated by Sternheimer, Hill et al., and This Report

The approach of this report provides sufficient accuracy in the determination of this effect by considering the electrons of each shell. The tabulation of Hill et al. includes the contribution of the electrons in each subshell, and thus should provide slightly more accuracy at low energies. However, this effect becomes less significant with decreasing proton energy, and minor errors in an already small correction can easily be tolerated.

The polarization effect has been calculated for each material in the tables by using the following procedure:

$$\Delta = \sum_i f_i \ln \left[ 1 + \frac{T^2}{(E_i^2 r_i^2 + E^2 f_i)} \right] - \frac{T^2(1 - \beta^2)}{E^2} \quad (5)$$

where  $T$  is an energy which is found by solving the following equation:

$$\sum_i f_i \frac{\bar{E}^2}{(E_i^2 r^2 + T^2)} = \frac{1}{\beta^2} - 1 \quad (6)$$

where  $\bar{E}$  is the energy associated with the plasma frequency of the medium, and is given by

$$\bar{E}^2 = \frac{4\pi\hbar^2 N_o e^2 \rho Z}{mA} \quad (7)$$

The quantity  $f_i$  is the classical oscillator strength of the  $i$ 'th transition whose energy is  $E_i$ , and is found by dividing the number of electrons in the  $i$ 'th shell by the atomic number. The ratio,  $r$ , is a correction which normalizes the sum of the individual atomic ionization potentials calculated from the energy levels,  $E_i$ , and the classical oscillator strengths,  $f_i$ , to the values found experimentally. This ratio is greater than unity because the average of the states to which the electrons are excited lies above the ionization limit in the continuum (Refs. 16 and 17). For conductors this ratio is given with sufficient accuracy by

$$r = \exp \left[ \frac{\ln I_{adj} - \frac{1}{2} \sum_{i=1}^{j-1} f_i \ln(f_i \bar{E}^2) - \sum_{i=1}^{j-1} f_i \ln E_i}{\sum_{i=1}^{j-1} f_i} \right] \quad (8)$$

where  $j$  is the dispersion oscillator for the conduction electrons. For non-conductors the required relationship is

$$r = \exp \left[ \frac{\ln I_{adj} - \sum_i f_i \ln E_i}{\sum_i f_i} \right] \quad (9)$$

A few representative values of  $r$  and  $r^2$  are listed in table 1.

A further correction is required if the adjusted ionization potential of a material is determined experimentally when that material is in a gaseous state, and the energy loss is calculated for the solid state. The converse is also true. This effect is very small and can be omitted with a negligible sacrifice in the accuracy of the energy loss.



The contribution of the  $\bar{E}^2 f_1$  term in the denominator of the logarithmic factor in equation (5) has been included in all of the calculations, even though its contribution is small except for the conduction electrons where  $E_1^2$  is zero. As a result, the polarization effect correction which has been obtained is slightly smaller than that of Sternheimer, who neglected the  $\bar{E}^2 f_1$  term for all but the conduction electrons.

Table I

TYPICAL VALUES FOR  $r$  AND  $r^2$  OBTAINED FROM EQUATIONS (8) AND (9)

<u>Element</u>	<u>Atomic number</u>	<u><math>r</math></u>	<u><math>r^2</math></u>
Lithium	3	1.014	1.028
Beryllium	4	1.488	2.216
Aluminum	13	2.446	5.987
Copper	29	1.498	2.245
Silver	47	1.495	2.236
Gold	79	1.201	1.442
Lead	82	1.212	1.469
Uranium	92	1.161	1.347

#### 4. The Adjusted Ionization Potentials

Most of the adjusted ionization potentials which have been used in performing the calculations were selected from the theoretical and experimental evaluations available from the literature (Refs. 19 through 40, 137 through 140; Table II). When elements having known adjusted ionization potentials bracket an element whose potential is unknown, linear interpolation has been used to obtain the unknown value. In the cases of manganese and tin, it was possible to estimate the necessary ionization potentials from the energy loss data at low energies. This is a highly dubious procedure, and the results appear to be a little low when compared with the  $I/Z$  values of the neighboring elements.

Theoretical estimates using hydrogenic wave functions and approximation techniques would be expected to give good results for very low atomic number elements. Such estimates have been made by Dalgarno (Ref. 22), and his numbers have been used for the adjusted ionization potentials for the atomic state of the first three elements, hydrogen, helium, and lithium. For the molecular state of hydrogen, the recent measurement by Martin and Northcliffe has been used (Ref. 23).

TABLE II  
A SURVEY OF ADJUSTED ION

ATOMIC NUMBER	ELEMENT	HALL REF. 19	BICHSEL REF. 19	WARSHAW REF. 20	BICHSEL REF. 21	DALBARNO REF. 22	MARTIN, NORTHCLIFFE REF. 23	ZRELOV, STOLETOV REF. 24	THOMPSON REF. 25	BICHSEL, UEHLING REF. 26	BAKKAS VON FRIESEN REF. 27	BAKKER SEGRE REF. 28	HBS HNDK 78 REF. 29	
1	HYDROGEN (ATOMIC)					14.8								
1	HYDROGEN (MOLECULAR)						18.3 ± 2.6	15	18.2			15.6	19 <sup>a</sup>	
2	HELIUM	40				41.7							43 <sup>a</sup>	
3	LITHIUM					38.8						34.		
4	BERYLLIUM			64	64	66.1		61 ± 6				60.4		
6	CARBON (ATOMIC)	60						85 ± 8	70.2			76.4	67 <sup>a</sup> , 72 <sup>a</sup>	
6	CARBON (MOLECULAR)		90 ± 2.4						77.3					
7	NITROGEN (DIATOMIC)				92		79. ± 7						84 <sup>a</sup> , 91 <sup>a</sup>	
7	NITROGEN (COMPOUNDS)								76.3					
8	OXYGEN (DIATOMIC)								79.8				89 <sup>a</sup> , 104 <sup>a</sup>	
8	OXYGEN (COMPOUNDS)								86.3					
10	NEON				140								80 <sup>a</sup>	
13	ALUMINUM		163 ± 3.7	156						163		150	161 <sup>a</sup>	
14	SILICON		170 ± 5.1											
17	CHLORINE								153.7					
18	ARGON				206		190. ± 17						190 <sup>a</sup>	
26	IRON	430			287			273 ± 22				243		
28	NICKEL				312									
29	COPPER			320	323			305 ± 10			322	278	313 <sup>a</sup>	
32	GERMANIUM		350 ± 10.											
36	KRYPTON				360									
42	MOLYBDENUM				420									
45	RHODIUM													
47	SILVER		470 ± 14.	490	470							428		
48	CADMIUM				480			468 ± 35						
50	TIN				500							479		
54	XENON													
73	TANTALUM				720									
74	TUNGSTEN							680 ± 30				657		
79	GOLD			790	780								636 <sup>a</sup>	
82	LEAD				810						818	754		
92	URANIUM	1200									908	861		

- <sup>a</sup> CALCULATED IN THE REFERENCED SOURCE FROM THE DATA OF BROLLEY AND RIBE (REF. 63)  
<sup>b</sup> CALCULATED IN THE REFERENCED SOURCE FROM THE DATA OF REYNOLDS, ET AL. (REF. 58)  
<sup>c</sup> CALCULATED IN THE REFERENCED SOURCE FROM THE DATA OF KARN (REF. 54)  
<sup>d</sup> THESE DATA POINTS WERE TAKEN BETWEEN 625 AND 651 MeV, DIFFERENT VALUES WERE OBTAINED FOR LOWER ENERGIES

A

TABLE II  
LIST OF ADJUSTED IONIZATION POTENTIALS

BAKKER SEGRE REF. 28	NBS HUBBARD REF. 29	BURKES, MACKENZIE REF. 30	CALDWELL REF. 31	HUBBARD MACKENZIE REF. 32	SIMMONS REF. 33	TURNER REF. 34	JATHEN, SEGRE REF. 35	BICHSEL MOZLEY, ARON REF. 36	BLOEMBERGEN VAN HEERDEN REF. 37	ALLISON WATSON REF. 52	GARCIA REF. 136	SACHS RICHARDSON REF. 157, 158	BOGARDY KOUDELS REF. 139	KRAZER-AGEYEV MASHKOVICH REF. 140 <sup>****</sup>	SHAPIRO REF. 40
											150			142.7	14.0
15.8	19°										1852.5		17.12.3		18.0
	43°										415		3522.7		
34.											35 ± 3.5				38.0
60.4		64					59	63.42.5		57					60.0
76.4	67°, 72° <sup>***</sup>						74.4						700	79 ± 5	60.0
															71.0
	84°, 91° <sup>***</sup>					89°							76.22.3.8		78.0
															90.0
	89°, 104° <sup>***</sup>												96.32.4.8		77.0
															98.0
	90°												130.62.2.0		
150	161° <sup>***</sup>	166.4	183.12.3	170	155.23		147.9	166.42.1	162.5	162		164	151 ± 3.7	1362.8	164.0
	190°					189°							226 ± 2.3		183.0
243		328.8													
			363.19									399			
279	313° <sup>***</sup>	366	377.21.8				309.2	375.62.20	370			435		300 ± 12	
			656.2.65									799			
428		557	69° 150					585.140				796			
			354.14.1									792			
479			708.2.39									853		463.2.23	
						485°									
			962.25.4									1148			
697		920.5													
	836° <sup>***</sup>	997	1136.2.00					1037 ± 100				1383			
758		1070					810.7		970					753.2.37	
831															

Selection of an ionization potential for beryllium is made somewhat arbitrary by the wide variance of values in the literature. The available estimates range from 57 ev to 64 ev. If beryllium ionization potentials are obtained from energy loss data near 1 Mev without application of a K shell correction, the results obtained from such a procedure are about 2 ev higher than would be expected otherwise. A value of 61 ev has been selected as a compromise (Ref. 24), and provides good agreement with the available data.

The carbon, nitrogen, oxygen, and chlorine values were obtained from the renormalized data of Thompson (Refs. 25, 29). The readjusted chlorine value seems to be low, but it is the only available experimental point. Since all of the other updated Thompson potentials produce excellent results, his experimental value has been used instead of the theoretical result of Brandt (Ref. 40).

Adjusted ionization potentials for a number of materials have been determined by Bichsel (Refs. 19, 21). His numbers have been used for neon, silicon, argon, germanium, nickel, molybdenum, tantalum, and gold.

For aluminum the recent data points strongly to 163 ev, and this value gives results which are in excellent agreement with several sets of experimental data.

Zrelov and Stoletov have made the most recent high-energy range measurements for iron and cadmium (Ref. 24). Their experiment was conducted using reliable techniques to determine the energy and estimate the multiple scattering, and gives 273 ev for iron and 468 ev for cadmium. Both of these results have been used.

The Subcommittee on Penetration of Charged Particles of the National Research Council has suggested that 314 ev be used for copper; however, when this was tried the resulting energy losses and ranges were not in sufficiently good agreement with the bulk of the experimental data. The value of 320 ev (Ref. 20) produces results which are in noticeably better agreement with the low energy experimental data than those obtained using 314 ev.

An inconsistency also exists in the various available adjusted ionization potentials for silver. Most of the values in the literature appear to be much too high. The linearly scaled value of 465 ev from the Bakker and Segre experiment (Ref. 26) produces results which are in very good agreement with the available experimental data.

Barkas and von Friesen have made high-energy experimental measurements of the copper, lead, and uranium ionization potentials, using a detailed Monte

Carlo technique to estimate multiple scattering and other effects. Their copper value of 322 ev is quite close to that which was finally selected for use in this report. Their lead and uranium values are the most recent available and have been used.

Many experimental determinations of the adjusted ionization potential are inaccurate because both the multiple scattering and nonparticipation of the inner shell electrons in the stopping process have not been accounted for with sufficient accuracy. These are significant effects in elements of medium and high atomic numbers. The error limits assigned by experimenters are also often underestimated and are not consistent with data from other sources.

The adjusted ionization potentials listed in table III were carefully selected to give results which are in good agreement with most of the available experimental data. In each case where a sufficient amount of experimental information was available, other values were tried and comparisons with the data were made. The final selection of an adjusted ionization potential for a given element was made on a pragmatic basis wherever possible.

The relationship between the adjusted ionization potential,  $I_{adj}$ , and that obtained from rigorous theoretical considerations,  $I'$ , depends upon the assumption of vanishing shell corrections in the extreme relativistic limit. The numerical value of  $I'$  can in principle be found by summing all of the electronic excitation and ionization levels over the entire electron population of the atom, while multiplying by the respective oscillator strengths of each individual electron. This proves to be quite difficult and has been done for only a few elements.

Nevertheless,  $I_{adj}$  and  $I'$  are related through the magnitude of the shell corrections at very high velocities. Fano and Turner (Ref. 12) have shown that the shell corrections do not actually vanish at high energies, but tend toward a finite limiting value, which they have calculated for several materials. Their tabulations are presented in table IV.

The relationship between  $I_{adj}$  and  $I'$  can be represented by

$$\ln I_{adj} = \ln I' + [\sum_i C_i/Z] \Big|_{\beta=1} \quad (10)$$

hence,

$$\ln I' = \ln I_{adj} - [\sum_i C_i/Z] \Big|_{\beta=1} \quad (11)$$

Table III

## ADJUSTED IONIZATION POTENTIALS

Reference	Element	Z	I/Z	I <sub>adj</sub> (ev)
22	H (Atomic)	1	14.80	14.8
23	H (Molecular)	1	18.30	18.3
22	He	2	20.85	41.7
22	Li	3	12.93	38.8
24	Be	4	15.25	61.0
Interpolated	B	5	13.60	68.0
25	C (Atomic)	6	12.52	75.1**
25	C (In compounds)	6	12.88	77.3**
29	N (Diatomic)	7	12.50	87.5 (Averaged)
25	N (In compounds)	7	14.21	99.5**
25	O (Diatomic)	8	11.11	88.9
25	O (In compounds)	8	12.31	98.5
Interpolated	F	9	13.41	120.7
21	Ne	10	14.00	140.0
26, 21	Al	13	12.54	163.0
19	Si	14	12.14	170.0
25	Cl	17	10.00	170.0**
21	Ar	18	11.39	205.0
*	Mn	25	10.12	253.0
24	Fe	26	10.50	273.0
Interpolated	Co	27	10.83	292.5
21	Ni	28	11.14	312.0
35	Cu	29	11.03	320.0
19	Ge	32	10.98	350.0
21	Mo	42	10.00	420.0
28	Ag	47	9.89	465.0***
24	Cd	48	9.75	468.0
*	Sn	50	9.70	485.0
21	Ta	73	9.86	720.0
20, 21	Au	79	9.87	780.0
21, 35	Pb	82	9.88	810.0
27	U	92	9.87	908.0

\*Determined from the experimental energy loss data of Green, Cooper, and Harris (Ref. 41) using the shell corrections of Reference 73.

\*\*These values were renormalized in Reference 29 and have been used here.

\*\*\*Linearly rescaled to a value of 163 ev for aluminum.

Table IV

LIMITING VALUES OF THE SHELL CORRECTIONS IN THE EXTREME RELATIVISTIC LIMIT (Ref. 12)

<u>Element</u>	<u>Atomic number</u>	$\left. \frac{\sum_i C_i}{Z} \right _{\beta = 1}$	$\left. \sum_i C_i \right _{\beta = 1}$
Beryllium	4	0.000	0.000
Aluminum	13	0.002	0.026
Argon	18	0.003	0.054
Copper	29	0.007	0.203
Silver	47	0.014	0.658
Lead	82	0.039	3.198
Uranium	92	0.051	4.692

where  $\left. \frac{\sum_i C_i}{Z} \right|_{\beta = 1}$  is the value for the total shell correction in the extreme relativistic limit, and can be obtained for some materials from table IV.

It should be emphasized that the assumption of vanishing shell corrections has been made in all of the calculations which have been performed. As long as these corrections and the associated  $I_{adj}$  values are applied consistently, this approach provides final results equivalent to those obtained by using  $I'$  and nonvanishing corrections.

When no data concerning the adjusted ionization potential were available, the procedure which is discussed in the following paragraphs was used.

Using the Thomas-Fermi model of the atom, Bloch found that for elements with sufficiently large atomic numbers, the adjusted ionization potential should be proportional to the atomic number according to the following relation (Ref. 38):

$$I = kZ \quad k \approx 10 \quad (12)$$

While predicting the correct trend, this expression does not result in particularly accurate results when compared to the data of table III. Brandt (Refs. 39, 40) has shown that a more detailed theoretical approach results in an equation of the following form:

$$I = kZ \left[ 1 + \frac{a}{Z^{2/3}} \right] \quad (13)$$

This equation has been slightly modified and was used to fit the data of table III over two regions to provide the additional adjusted ionization potentials which were required.

$$I_{\text{adj}} = 10.11Z \left[ 1 + \frac{(Z - 27)^2}{148 Z^{2/3}} \right] \quad 10 < Z < 25 \quad (14)$$

$$I_{\text{adj}} = 9.78Z \left[ 1 + \frac{0.196}{Z^{2/3}} \right] \quad Z > 33 \quad (15)$$

The halogens and the noble gases tend to depart somewhat from these relationships, but all of the other adjusted ionization potentials listed in table III are fit quite well. The value of the constant "a" in equation (14) has been allowed to assume a residual dependence on the atomic number in order to improve the accuracy of the fit. All values not available from table III were calculated from the above equations with the exception of zinc, which was obtained using the I/Z ratio for copper.

Although the decrease of the ratio I/Z with increasing atomic number is evident, minor deviations are present. The binding effects of the valence electrons in conductors along with the polarization effect are both contributing factors. Some of the irregularities in the elements of low atomic number are undoubtedly the result of statistical effects bearing upon any averaging process which involves only a few atomic electrons.

The high I/Z values for helium and neon are probably the result of the tight electron binding due to the closed shells. This effect is not as pronounced in the other inert gases because the number of electrons which reside in the inner shells are not appreciably affected by the closing of an outer shell.

A small departure from the decreasing trend of I/Z occurs for the elements having atomic numbers between 26 and 42. Green et al. (Ref. 41) find evidence of a periodic fluctuation resulting from the order in which the atomic shells are filled. Electrons are added to the outer s and p shells from hydrogen to argon, but beginning with scandium, the 3d shell begins to be filled. Between copper and krypton, the 4s and 4p shells are being filled. The conduction metals (21 < Z < 30) also have large electronic specific heats, and Bader et al. (Ref. 42) have suggested that this might be interpreted in terms of an increased "effective" mass of the electrons in the valence states. As a result, energy loss by protons to these electrons could be reduced if this effect carries over to charged particle interactions. The increase in I/Z for nickel and copper, in particular, has been reasonably well verified experimentally.



In the calculation of the energy loss in compounds and mixtures, the concept of an effective ionization potential for that compound or mixture has not been employed. This would have required that an "average" shell correction also be applied, which is not the procedure which yields the most satisfactory results. The energy loss in materials composed of both low and high atomic number materials cannot be properly determined using such an "average" shell correction. Although the approach used in this report depended on the additivity of the energy loss rather than on the existence of an effective additive ionization potential, it was felt that this quantity could be useful for high energy approximate calculations over a limited energy range. It has been calculated for both compounds and mixtures and printed at the bottom of the last data page. The following equation was employed in the calculation:

$$I_{\text{eff}} = \exp \left[ \frac{\sum_i n_i Z_i \ln I_i}{\sum_i n_i Z_i} \right] \quad (\text{ev}) \quad (16)$$

where

$n_i$  = the number of atoms per cubic centimeter of the  $i$ th element of the compound

$Z_i$  = the atomic number of the  $i$ th element of the compound

$I_i$  = the adjusted ionization potential of the  $i$ th element of the compound

As no molecular binding energy is associated with mixtures of elements, the additivity of the energy loss for such mixtures should be strictly correct.

##### 5. Discussion of the Energy Loss Below 1.0 Mev

Equation (3) has been used to calculate the energy loss by protons above 1.0 Mev, which is always above the limiting energy given by equation (4). This is about 0.4 Mev for uranium and less for all other natural elements. Even at energies near 1.0 Mev in heavy elements the Bethe equation yields results which are in good agreement with the available experimental data if the equation is modified with the necessary shell corrections.

At very low energies a point is eventually reached where the proton capture cross section for atomic electrons becomes significant. The capture process is more probable for very low energy protons, while the electron loss cross section predominates at energies above 0.5 Mev. Hall (Ref. 43) has found that the ratio of the capture to loss cross sections remains relatively constant for most materials. Thus, a low-energy proton traversing matter may have a rapid exchange of electrons with the nearby atoms of the absorber. This has the net effect of reducing the effective charge of the proton to a value which is less than unity.

The relation between the effective charge,  $z_{\text{eff}}$ , and the ratio of the capture-to-loss cross sections for protons near electron exchange equilibrium can be shown to be

$$z_{\text{eff}} = \frac{1}{1 + \sigma_c/\sigma_L} \quad (17)$$

Kanner (Ref. 44) has made accurate experimental measurements on the electron capture-and-loss cross sections for protons passing through air, and finds that the following equations are a good fit to his experimental data:

$$\sigma_{\text{loss}} = (24.54 - 0.866 E/T_0) \times 10^{-17} \text{ cm}^2 \quad 40 < E < 325 \quad (18)$$

$$\sigma_{\text{capture}} = 41.4 \exp(-0.562 E/T_0) \times 10^{-17} \text{ cm}^2 \quad 31 < E < 122 \quad (19)$$

where  $E$  is the proton kinetic energy in Kev, and  $T_0$  is 24.8 Kev.

The effective charge of a low energy proton can be readily determined from the above relations and equation (17), the results are illustrated in figure 3.

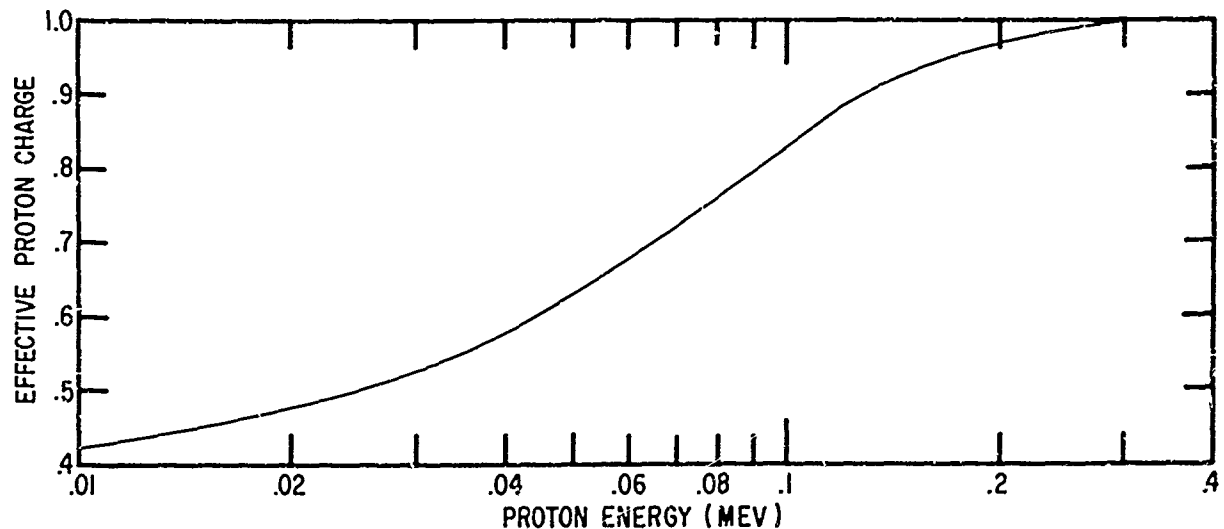


Figure 3. The Effective Charge of a Low Energy Proton

Although a considerable extrapolation has been required to obtain values of the effective charge above 0.3 Mev, the results indicate that protons above

0.5 Mev have a net charge of unity.

The shell corrections which must be applied to the Bethe equation are somewhat inaccurate in the heavier elements at these very low energies. When the shell corrections and the above relationships concerning the effective charge were applied to equation (3) below 1.0 Mev, the results were marginal for the light elements, but were in disagreement with the bulk of the empirical information which is available for the medium and heavy elements. These results were particularly disappointing at energies near 0.1 Mev. The appropriate shell correction functions were applied, but did not provide a sufficient improvement in the accuracy at these very low energies. As a result, final shell corrections were applied which yielded the most accurate and consistent results near and above 1.0 Mev, and no calculations using the Bethe equation were carried out below 1.0 Mev. The procedure described in the next paragraph allowed the low energy ionization to be determined in a much more reliable and accurate manner than did further extension of the Bethe equation.

The energy loss below 1.0 Mev has been found by smoothing, interpolating, and in some cases extrapolating the available experimental information. A sufficient amount of experimental data is available between 0.1 and 0.8 Mev to make this approach practical. The energy loss from 0.8 to 1.0 Mev has been determined by performing an interpolation in this region.

The excellent summaries and review articles which are available (Refs. 45 through 53) have been drawn upon as sources of some low-energy data and were used in conjunction with the published reports of the original experimenters (Refs. 54 through 64). Where several sets of experimental data were available and the results of each were within the estimated error of the other, the data were averaged. In those cases where two or more experiments were available and did not agree, a selection of the input data was made on the basis of consistency by comparing the shape and numerical value of the data in question with other sets of data for elements of similar atomic number. The scatter of the selected sets of data has been reduced by least squares smoothing techniques. The entire selection process usually favored the most recent experimental data.

After the final sets of experimental data were selected, curves were fitted through the experimental points to obtain a smooth relationship between proton kinetic energy below 0.8 Mev and the corresponding energy loss. These curves were obtained by again using the method of least squares. These curves were then used as input to the computer program to obtain the energy loss below

0.8 Mev for elements having the following atomic numbers: 1, 2, 3, 4, 6, 7, 8, 9, 10, 13, 18, 20, 23, 24, 25, 26, 27, 30, 32, 34, 36, 47, 50, 51, 54, 73, 79, and 82. In some cases, an "unusual" data point or some systematic error appeared to exist in some of the original input data. Such data were disregarded in favor of interpolation between the two nearest data points or elements for which reliable data existed. There are certain dangers in an approach of this type, nevertheless, the overall error at low energies is still much less than could have been legitimately obtained by use of the Bethe equation.

For elements having atomic numbers greater than 82, an extrapolation was performed by renormalizing the experimental energy loss data in lead at 1.0 Mev to the theoretical value obtained from the Bethe equation at 1.0 Mev, and then scaling the magnitude of this energy loss below 1.0 Mev in lead by using the following relation:

$$\frac{1}{\rho} \frac{dE}{dX} = \left[ \frac{1}{\rho} \frac{dE}{dX} \right]_{\substack{E < 1.0 \\ \bar{r}_b, \text{exp}}} \left\{ \frac{\left[ \frac{1}{\rho} \frac{dE}{dX} \right]_{\substack{E = 1.0 \\ Z_i, \text{calculated}}}}{\left[ \frac{1}{\rho} \frac{dE}{dX} \right]_{\substack{E = 1.0 \\ \text{Pb, calculated}}}} \right\} \quad \begin{array}{l} Z > 82 \\ E < 1.0 \end{array} \quad (20)$$

where  $Z_i$  is the atomic number corresponding to the element in question. This procedure was adopted since no complete proton energy loss measurements over the energy range from 0.1 to 0.8 Mev were found in the literature for materials between lead and uranium, although some data is available for bismuth down to 0.4 Mev. Since the energy loss at a fixed energy is a slowly varying function of the atomic number in the heavy elements, this approach should provide realistic answers, although the absolute accuracy is difficult to determine.

## 6. Shell Corrections

Protons of moderate energy traversing heavy elements and of very low energy in lighter elements have velocities comparable to the velocities of the inner shell electrons. This velocity, and thus the binding energy of an atomic electron in a given shell, determines the participation of that electron in the proton stopping process. It cannot be assumed that such an electron will be ejected from an atom if the energy transferable by the incident proton is greater than the binding energy of the electron. Conversely, this electron will not always interact if the transferable energy is less than the binding energy.

The probability that a bound electron will participate is not a simple step function because of the statistical effects bearing upon all systems which require a quantum mechanical description.

Although such calculations are difficult, correction terms which represent the nonparticipation of the inner shells in the slowing down process have been presented by several authors (Refs. 65 through 73). These modifications must be applied to maintain the velocity independence of the atomic ionization potential. At low energies, these compensation terms reach a maximum and then decrease. A point is eventually reached where the corrections must actually become negative to compensate for the low energy behavior of the logarithmic term within the brackets of equation (3). This has been briefly discussed by Walske (Ref. 67) and by Peele (Ref. 71). When this occurs, the shell correction terms actually dominate the behavior of the stopping power relation, particularly for elements of large atomic number.

Bichsel (Ref. 21) has used a semiempirical approach coupled with the method given by Walske to determine the necessary shell correction terms. He has assumed that the higher order shell corrections can be obtained by scaling the L shell function both in energy dependence and magnitude. The expressions for the nonparticipation of K and L shell electrons used for the calculations of this report have been obtained through application of high-order least-square curve fits to the data of Walske as presented by Bichsel in reference 4. The detailed results which were obtained are presented for several elements in figures 4 and 5 to illustrate their magnitude and energy dependence.

The L shell correction is of dubious validity when applied directly to the lighter elements. As a result, moderate extrapolation and modification of the magnitude of the L shell correction has been performed to permit the use of an L shell correction in the light elements. Even though the shell corrections are not relativistic, they have nevertheless been applied to the heavy elements where such effects might be significant.

Moderate extrapolations of the L shell functions presented in reference 4 has allowed a correction term for aluminum to be established. Since these correction terms are not known exactly for all elements, a linear interpolation has been used to determine the correction for other elements. This also allows a moderate extrapolation to be made to elements having atomic numbers less than 13. The following equation was used for both the interpolation and extrapolations for all the shell corrections, where the L shell is used as an example:

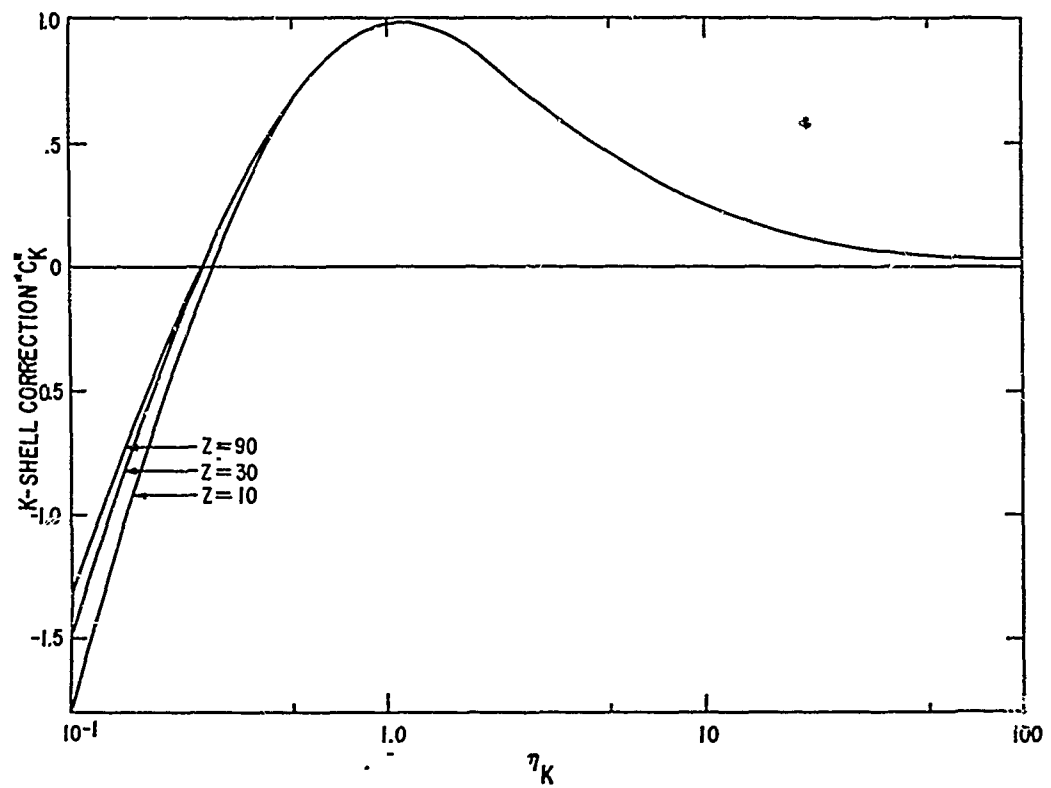


Figure 4. The K Shell Correction

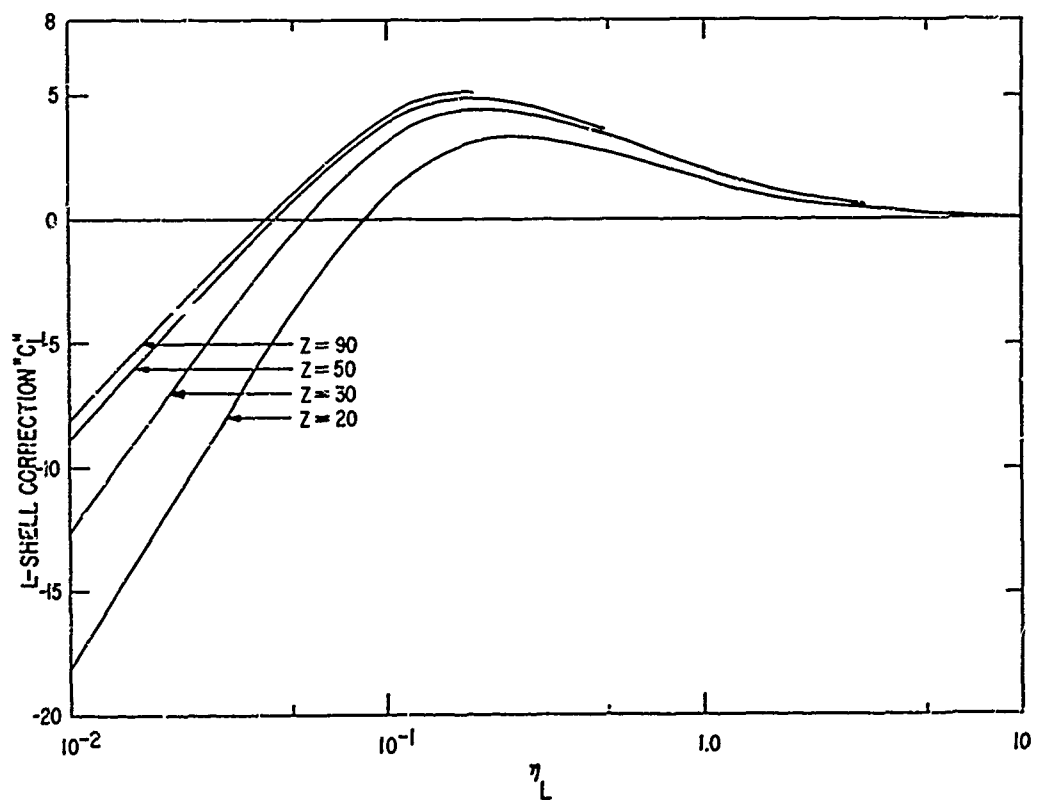


Figure 5. The L Shell Correction

$$C_L(Z') = \frac{[C_L(Z_1) - C_L(Z_2)][Z' - Z_1]}{Z_1 - Z_2} + C_L(Z_1) \quad (21)$$

When  $Z'$  is less than 13,  $Z_1$  and  $Z_2$  refer to atomic numbers 13 and 20, respectively. If  $Z'$  is greater than 13,  $Z_1$  and  $Z_2$  refer to the atomic numbers of the elements for which exact calculations are available, and whose atomic numbers bracket  $Z'$ .

There are two methods which can be used to determine the M shell correction term. A theoretical calculation of the M shell correction using a plane wave Born approximation form factor for collisions of the incident protons has been performed (Ref. 68). The M shell correction (and higher order corrections) may also be found by scaling the L shell correction both in magnitude and energy dependence. The magnitude of the scaled M shell correction should be proportional to the number of electrons in the M shell divided by the number of electrons in the L shell. The velocity dependence would be proportional to the ratio of the spectroscopic ionization potential of the M shell to that of the L shell.

When the M shell correction obtained from the scaling method is compared with the theoretical M shell correction calculated by Khandelwal and Merzbacher (Ref. 68), a serious difference is found in the magnitude and velocity dependence of the two corrections. The scaled correction results in energy-loss values which are usually in excellent agreement with experiment, while the theoretically calculated correction of Khandelwal and Merzbacher produces results which are noticeably different than those obtained with the scaling technique.

The scaled and theoretically calculated M shell corrections for  $Z = 80$  have been compared in figure 6. Errors of 10 or 15 percent might possibly exist in the scaled correction, but such errors are not large enough to explain the difference in the two curves. Khandelwal has indicated that the validity of the theoretical results might have been compromised as a result of using hydrogenic wave functions for the M shell (Ref. 69). For such calculations, methods using the Hartree-Fock or other similar atomic models for the M shell electrons would probably be more accurate. Such calculations are under way (Ref. 69) and would be expected to produce realistic correction terms for the intermediate shells. In addition, calculations for each subshell would be better than could be obtained by averaging over the entire shell. The scaled M, N, and O shell corrections have actually been obtained by calculating the

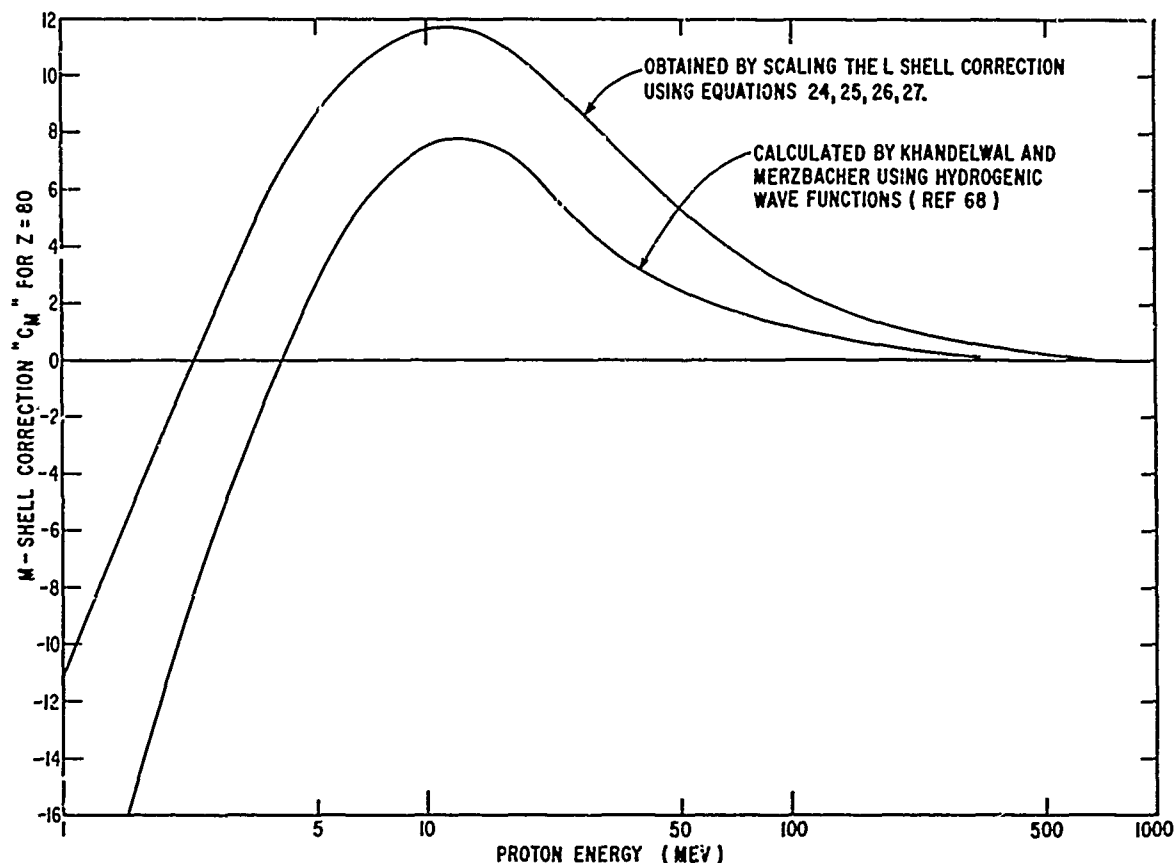


Figure 6. A Comparison of the M Shell Corrections Obtained from the Theoretical Calculations (Ref. 68) and by Scaling of the L Shell correction for each subshell, and then summing the results to obtain the total correction. The individuality of the subshells has been accounted for in this manner.

Since the scaled M shell correction produces results which are in quite good agreement with the bulk of the experimental data, it has been used instead of the theoretically derived functions of reference 68.

The approach and corrections used in this report are essentially those developed by Walske and evaluated by Bichsel. It should be noted that no artificial scaling of the magnitude other than that obtained by using the ratio of the electrons in each shell was required for the M shell. This may be a result of the method used to initially interpolate the L shell correction between elements of various atomic numbers. Such effects would be cumulative, since the higher order shell corrections depend directly on the numerical value and energy dependence of the L shell correction for a given element.

The higher order shell terms have been found by scaling the L shell correction of Walske both in magnitude and energy dependence in the following manner.



A separate correction has been applied to each of the three subshells in the M shell, to the four subshells in the N shell, and to each of the three filled subshells of the O shell. The two doublet energy levels of each subshell have been averaged to obtain a mean ionization potential for that subshell.

The quantities  $\eta_K$  and  $\eta_L$  are the parameters of Walske which are used in the computation of the K and L shell corrections:

$$\eta_K = \left[ \frac{\hbar c}{e^2} \right]^2 \left[ \frac{\beta^2}{(1 - \beta^2)(Z - 0.3)^2} \right] \quad (22)$$

$$\eta_L = \left[ \frac{\hbar c}{e^2} \right]^2 \left[ \frac{\beta^2}{(1 - \beta^2)(Z - 4.15)^2} \right] \quad (23)$$

The M shell correction is found by applying the following scaling relationships:

$$C_M = C_{M1} + C_{M2} + C_{M3} \quad (24)$$

$$C_{M1} = \left[ \frac{1}{4} \frac{(1 - \beta^2)}{\left(1 - \frac{\beta^2}{F} \frac{I_L}{I_{M1}}\right)} \right] \left[ C_L \left( \beta \sqrt{\frac{1}{F} \frac{I_L}{I_{M1}}} \right) \right] \quad (25)$$

$$C_{M2} = \left[ \frac{3}{4} \frac{(1 - \beta^2)}{\left(1 - \frac{\beta^2}{F} \frac{I_L}{I_{M2}}\right)} \right] \left[ C_L \left( \beta \sqrt{\frac{1}{F} \frac{I_L}{I_{M2}}} \right) \right] \quad (26)$$

$$C_{M3} = \left[ \frac{\gamma_3}{8} \frac{(1 - \beta^2)}{\left(1 - \frac{\beta^2}{F} \frac{I_L}{I_{M3}}\right)} \right] \left[ C_L \left( \beta \sqrt{\frac{1}{F} \frac{I_L}{I_{M3}}} \right) \right] \quad (27)$$

Likewise, the N shell correction is given by

$$C_N = [C_{N1} + C_{N2} + C_{N3} + C_{N4}] [1.2] \quad (28)$$

$$C_{N1} = \left[ \frac{1}{4} \frac{(1 - \beta^2)}{\left(1 - \frac{\beta^2}{S} \frac{I_L}{I_{N1}}\right)} \right] \left[ C_L \left( \beta \sqrt{\frac{1}{S} \frac{I_L}{I_{N1}}} \right) \right] \quad (29)$$

$$C_{N2} = \left[ \frac{3}{4} \frac{(1 - \beta^2)}{\left(1 - \frac{\beta^2}{S} \frac{I_L}{I_{N2}}\right)} \right] \left[ C_L \left( \beta \sqrt{\frac{1}{S} \frac{I_L}{I_{N2}}} \right) \right] \quad (30)$$

$$C_{N3} = \left[ \frac{\gamma_6}{8} \frac{(1 - \beta^2)}{\left(1 - \frac{\beta^2}{S} \frac{I_L}{I_{N3}}\right)} \right] \left[ C_L \left( \beta \sqrt{\frac{1}{S} \frac{I_L}{I_{N3}}} \right) \right] \quad (31)$$

$$C_{N4} = \left[ \frac{\gamma_7}{8} \frac{(1 - \beta^2)}{\left(1 - \frac{\beta^2}{S} \frac{I_L}{I_{N4}}\right)} \right] \left[ C_L \left( \beta \sqrt{\frac{1}{S} \frac{I_L}{I_{N4}}} \right) \right] \quad (32)$$

In each case, the quantity within the square brackets multiplies the L shell correction, which is found by assuming that the effective velocity of the incident proton is not given by  $\beta$ , but by the function of  $\beta$  which appears in parentheses immediately following  $C_L$ .  $I_L$  is the mean ionization potential of the L shell;  $I_{Mi}$  is the mean ionization potential of the i'th subshell of the M shell; and  $I_{Ni}$  is the mean ionization potential of the i'th subshell of the N shell.  $\gamma_3$  represents the number of electrons which are in the third subshell of the M shell for any given element. Likewise,  $\gamma_6$  and  $\gamma_7$  are the number of electrons in the d and f subshells of the N shell, respectively. The O shell correction has been obtained in an identical manner.

Values of the required ionization potentials for each shell and subshell are available in the literature (Refs. 74 through 77). Those of reference 74 have been used throughout. Interpolation has been performed for those elements whose subshell ionization potentials are not known.

The factor F is a scaling factor which varies slowly with atomic number. It is

$$F = 0.00189Z + 1.8452 \quad (33)$$

The factor S is a similar scaling parameter for the N shell and is given by

$$S = 0.15625Z + 1.2654 \quad (34)$$

The scaling factor for the O shell has been set equal to 2.0 for all elements. It should be noted that the justification for this scaling factor is entirely pragmatic and has been applied for the purpose of improving the accuracy of the final tabulations. Multiplication of the subshell corrections for the N shell by the factor of 1.2 was necessary because the positive maximum of the scaled N shell correction is not sufficiently peaked at low energies. The correction term is too small in this region unless the factor of 1.2 is applied.

The experimental data, particularly for the higher atomic number elements, could have been fit much more closely by carefully choosing scaling factors for each individual element; however, the entire method of calculating the corrections for the M, N, and O shells then loses a degree of internal consistency. It would then be difficult to maintain confidence in the calculations which have been performed for materials having no experimental data available upon which to establish these scaling factors.

No M shell correction has been applied to elements with an atomic number less than 20, and no N shell correction has been used for elements having atomic numbers less than 37. An O shell correction has been applied to all elements with an atomic number greater than 57.

Although the scaling procedure described previously works quite well, a small but consistent deviation is apparent. There is a sufficient amount of experimental energy loss data available for copper to allow a detailed comparison of the scaled M shell correction with that which could be obtained by using the Bethe equation with only K and L shell corrections and working in reverse order from the experimental data to determine the M shell correction. When this is done, the following conclusions may be reached concerning the scaled shell corrections.

Although the velocity dependence seems to be satisfactory, it appears that the shape of the scaled correction is not quite correct. It is not properly peaked at the maximum and does not decrease with a sufficiently steep slope on the low-energy side of this maximum. The same effect, but more pronounced, appears to hold true for the scaled N shell, and presumably for the next higher order correction although there is insufficient experimental data available to establish this for the O shell term. This discrepancy is particularly noticeable for the energy loss in lead near 1.0 Mev. At this point the O shell correction is positive and is beginning to be significant, while the N shell

correction is decreasing rapidly. This rate of decrease is not sufficiently steep to obtain good agreement with the experimental data.

Although they are undoubtedly present, such effects are not overly important for elements having atomic numbers below lead where the rapidly decreasing portion of the N shell correction is not as significant. It was felt that a compromise in the uniform application of the O shell correction might be made in lead to improve the tabulated energy loss at low energies. This can be done by reducing the magnitude of the O shell correction in elements having atomic numbers greater than 81. This offsets the discrepancy caused by the faulty shape of the N shell correction near 1.0 Mev. This has been done for lead, bismuth, and uranium under the assumption that for these elements the O shell correction is approximate but nevertheless necessary.

All of the correction terms for gold have been presented in figure 7 to illustrate predominance of the higher order shell corrections at low energies.

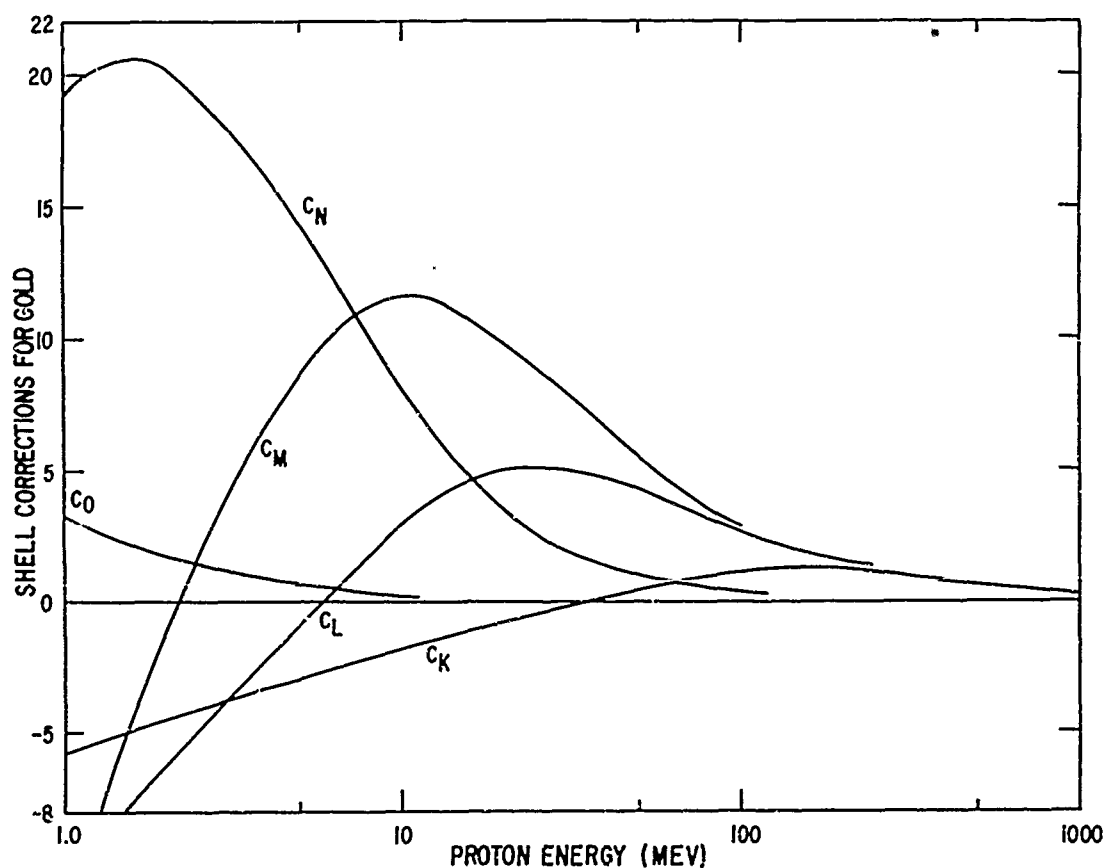


Figure 7. The K, L, M, N, and O Shell Corrections for Gold

## 7. The Assumption of Additivity

Inasmuch as chemical binding energies in compounds are usually very much smaller than the adjusted atomic ionization potentials, it has generally been assumed in previous calculations that the stopping power of a compound is the sum of the stopping powers of its individual constituents acting independently. Experimental studies by Thompson (Ref. 25) have shown that the stopping power of a compound can be approximated to within 2 percent under this additivity rule for 200- to 340- Mev protons in compounds containing hydrogen. This deviation decreased rapidly with compounds of increasing atomic number, becoming approximately 1 percent for the compounds which contained light elements other than hydrogen, and became negligible for atomic numbers greater than 17.

Reynolds et al. have used low-energy protons in gases to determine the validity of the additivity rule (Ref. 56). The materials tested were additive above 0.2 Mev with the exception of nitrous oxide, which had a stopping power about 4 percent higher than would have been expected assuming additivity.

For compounds containing significant amounts of low atomic number materials, especially compounds containing hydrogen, the small chemical binding effects of the additivity rule should be considered. For this reason, more than one ionization potential has occasionally been used for the same element, depending on whether the element is being discussed with reference to its atomic or its molecular state. This is admittedly an approximation procedure in that the ionization potential of any element in a compound also depends on the specific type and number of molecular bonds, but the results obtained by means of this procedure appear accurate enough to justify its use.

In general, the outer electrons are more tightly bound in compounds than they are in elements because of the molecular bonds. This has the effect of slightly raising the total adjusted ionization potential of each atom which is bound in the molecule. For mixtures of elements, no such binding occurs, and the additive rule should be strictly correct.

The comparisons which have been made in the appendix indicate that several comments concerning the additive rule be made. Water is a rather stringent test of the additive rule, since the water molecule is quite strongly bound. The adjusted ionization potentials which have been used for hydrogen and oxygen in their molecular forms are slightly higher than the ones used for the atomic state. This approach works very well for water, and for most of the other

compounds as well. However, the calculations for nuclear emulsion at high energies are 2 or 3 percent different from the high energy experimental emulsion data. The energy loss and pathlength for nuclear emulsion are known with accuracies on the order of 1 percent. It is apparent that the low energy results are very good, but that the high energy pathlengths are outside of the experimental error by 1 or 2 percent. This is puzzling in view of the excellent agreement in the other cases.

#### 8. Minimum Ionization Point

The minimum value of the energy loss per unit pathlength occurs at proton energies near 2 Bev and is caused by relativistic effects, which are included in calculations using equations (1), (2), and (3). The minimum ionization has been illustrated for aluminum in figure 8. The shell corrections are very small in this energy region and change quite slowly so that they can be treated as constant over a limited energy range. Near the point of minimum ionization, the polarization effect is negligible for gases and is usually small for condensed media. Thus, these two effects have not been considered in obtaining the kinetic energy at which minimum ionization occurs, although they have been applied in determining the minimum ionization itself.

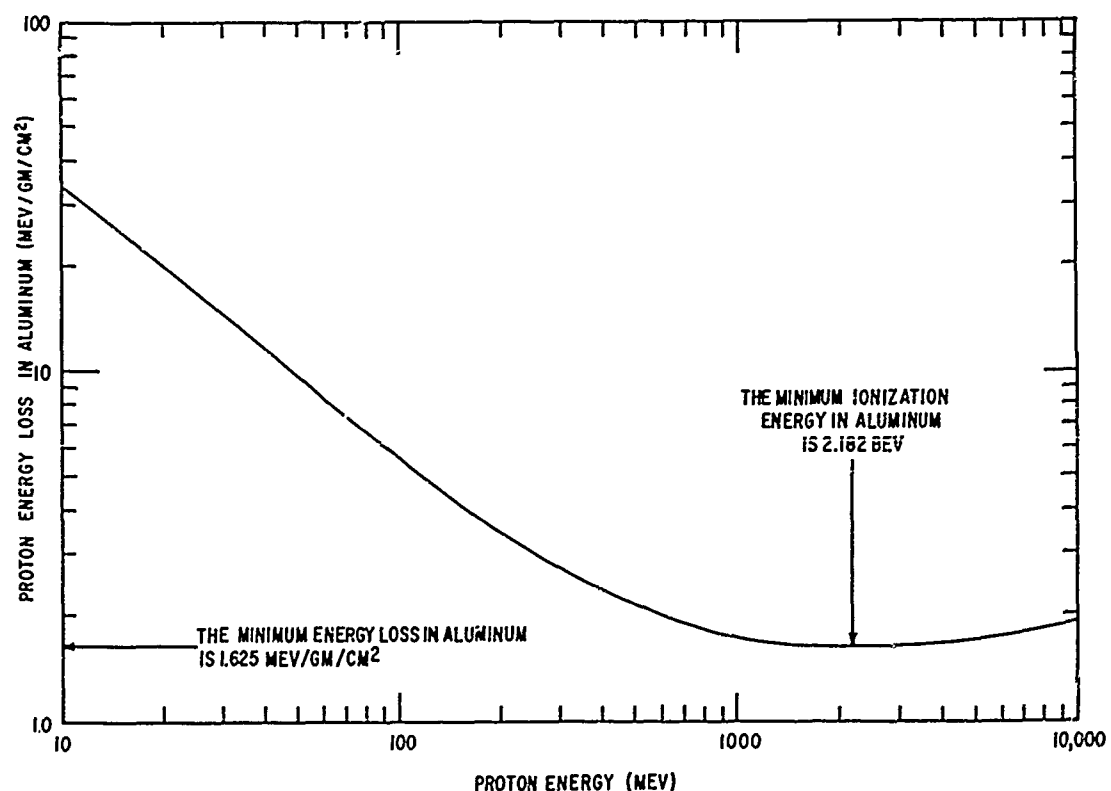


Figure 8. The Minimum Ionization Loss for Protons in Aluminum

In order to determine the point of minimum ionization, equation (3) has been differentiated with respect to the proton velocity, equated to zero and solved for that value of the proton velocity which minimizes the original Bethe equation. The shell corrections and polarization effect have not been considered in the differentiation.

The derivative of the Bethe equation with respect to particle velocity gives

$$\frac{d}{d\beta} \left[ \frac{1}{\rho} \frac{dE}{dX} \right] = - \frac{8\pi m z^2 e^4 N Z}{m c^2 \beta^3} \left\{ \ln \frac{2 m c^2 \beta^2}{I_{adj} (1-\beta^2) \sqrt{1 + \frac{2m}{M\sqrt{1-\beta^2}} + \left(\frac{m}{M}\right)^2}} \right. \\ \left. - \frac{1}{1-\beta^2} - \frac{\left(\frac{m}{M}\right) \beta^2}{2 \left[ 1 + \frac{m}{M\sqrt{1-\beta^2}} + \left(\frac{m}{M}\right)^2 \right] (1-\beta^2)^{3/2}} \right\} \quad (35)$$

The above function was then equated to zero and solved for the velocity which minimized equation (3). The expression within the braces is the equation which must be actually solved. This equation cannot be solved using analytic methods when  $\beta$  is close to unity. It has been solved numerically on the computer using a Newton-Raphson iteration technique. The solution is presented on the bottom of the page of tabulations for each material.

The only factor within the braces which is characteristic of the absorbing material is the mean ionization potential. Since this equation is to be solved at an energy which is always near 2 Bev, the effective ionization potential (equation (16)) has been used to obtain the solution for both compounds and mixtures. This could not have been done were the minimum ionization point to occur in a region where both the shell corrections and the polarization effect could not be neglected in the differentiation. Since the solution varies very slowly with the atomic number of the material, the actual results should be quite accurate even with the aforementioned assumptions.

## SECTION III

## PATHLENGTH AND RANGE CALCULATIONS

1. Integration of the Energy Loss to Determine the Pathlength and Range

Determination of the mean pathlength is straightforward and can be made through the following numerical integration:

$$P(E_0) = P(0.1 \text{ Mev}) + \int_{0.1}^{E_0} \frac{1}{\rho} \frac{dE}{dX} \quad (36)$$

where  $P(E_0)$  is the total mean pathlength for protons of initial kinetic energy " $E_0$ ," and  $P(0.1 \text{ Mev})$  is the pathlength at 0.1 Mev. The integration has been normalized at 0.1 Mev because values of the  $dE/dX$  at very low energies are not known. The pathlength has been normalized to the data which are available at 0.1 Mev; the specific values which have been used were taken from the review article by Whaling (Ref. 53). In those cases where no experimental or other reliable data were available, an approximate first-order curve was fitted to the available data. This curve is

$$P(0.1 \text{ Mev}) = 0.06593 + 0.01586Z \quad (\text{gm/cm}^2) \quad (37)$$

Since the energy loss below 1.0 Mev is actually given by smoothed and interpolated experimental data, any discrepancies in the low energy pathlengths result from the value of the pathlength selected at 0.1 Mev if one assumes that the experimental energy loss is free from significant error. This assumption is usually justified, but the smoothing process which has been used cannot eliminate systematic errors, which may be present in some of the data. The pathlengths at high energies only have a small dependence on the value selected at 0.1 Mev. For example, if the pathlength in nitrogen at 0.1 Mev is set equal to zero, the pathlength at 1.0 Mev is decreased by 4.8 percent, at 10.0 Mev by only 0.095 percent, and at 100 Mev by the negligible percentage of 0.0015.

In calculating the pathlength at 0.1 Mev for compounds, the following equation was used:

$$\frac{1}{P} = \sum_{i=1}^n \frac{w_i}{P_i} \quad (38)$$



where  $w_i$  is the percent by weight of the  $i$ th element in the compound which contains  $n$  elements, and  $P_i$  is the mean pathlength of 0.1 Mev protons in the  $i$ th element.

The range of a proton in an absorbing medium will be somewhat smaller than the pathlength as measured from the original angle of incidence into the material, because the proton will undergo multiple coulomb scattering. The range can be calculated by means of the following relation:

$$R(E_o) = R(0.1 \text{ Mev}) + \int_{0.1}^{E_o} \frac{\langle \cos \theta \rangle}{\frac{1}{\rho} \frac{dE}{dX}} dE \quad (39)$$

where  $\langle \cos \theta \rangle$  is the mean value of the cosine of the projection of the total scattering angle onto a plane which contains the original trajectory. Calculations of this quantity have been performed using equation (42), which is straightforward but extremely tedious and is discussed in a later section. The procedures outlined by equation (39) are also very time-consuming on the computer because a double integration must be performed using very fine increments of integration.

Although the proton straggling can be represented approximately by a gaussian distribution, the multiple scattering has an asymmetry which results from the contribution of the infrequent large angle scatterings. As a result, the average range is slightly different from the probable range, although such differences for protons are usually small in cases involving large energy losses.

No attempt has been made here to evaluate the most probable energy loss and pathlength even though the differences may be significant for protons passing through thin absorbers. Such calculations can be performed using the energy loss relationship given by Landau (Ref. 78). All of the calculations which have been tabulated here are average values, and are strictly applicable only when the protons have traversed a sufficient amount of material to make average values meaningful. This is the case for thick target shielding situations where protons lose most or all of their kinetic energy in the absorber.

## 2. Pathlength Straggling

Protons lose kinetic energy to an absorbing medium in small discrete amounts as they undergo a multitude of collisions with atomic electrons. Since this is mainly a statistical process, an initially monoenergetic beam of protons will

have a definite energy spread after passing through a finite thickness of absorber. A statistical distribution will therefore exist in the energy lost by protons which have traveled identical paths in the stopping material. There will also be a small but definite straggling about the mean pathlength (Refs. 79 through 81). The root mean square straggling (the standard deviation of the distribution) has been found using the expression given by Sternheimer (Ref. 79).

$$\sigma^2 = \frac{4\pi e^4 z^2 N_o Z}{A} \int_E^{E_o} \frac{(1-\beta^2/2)}{(1-\beta^2)} \left[ \frac{1 + \frac{4\sum_i f_i E_i}{3mc^2 \beta^2} \ln \frac{2mc^2 \beta^2}{E_i}}{\left[ 1 + \frac{2m}{M\sqrt{1-\beta^2}} + \left(\frac{m}{M}\right)^2 \right]} \right] \left( \frac{1}{\rho} \frac{dE}{dX} \right)^3 dE \quad (40)$$

The value of  $\sum_i f_i E_i$  depends upon the ionization potential of each atomic shell and the number of electrons in those shells which participate in the stopping process for low energy protons. This dependence becomes less significant at higher energies. The value of  $\sum_i f_i E_i \ln \frac{1}{E_i}$  can be represented in equation (40) with sufficient accuracy by summing over the classical oscillator strength and shell binding energy of every electron in each atomic shell which is capable of participating in the energy loss process. This has been done in detail for each material at all energies.

A classical technique has been used to determine the possibility of incident protons ejecting electrons from atomic shells. If the maximum energy transfer given by equation (2) is greater than the binding energy of electrons in an atomic shell, then those electrons are assumed to be capable of participation in the energy loss process. If the maximum energy transferable is less than the binding energy of the shell, those electrons may not participate. These two assumptions have been applied only to equation (40), where this classical technique is more than satisfactory.

The summation indicated in the numerator of equation (40) does not produce a perfectly smooth function, but is slightly irregular because of the abrupt cutoff which occurs near the binding energy of each atomic shell. This termination point for a given shell corresponds to the region where the quantum mechanically derived shell correction for that shell reaches a maximum. In this case, the classical approach provides results for use in equation (40) which are quite adequate.

In the calculation of  $\sigma$  for compounds, it has been assumed that the pathlength straggling is due exclusively to the effects of each atom acting independently

of the molecular structure. Values of  $\sigma$  have been tabulated under the heading "Pathlength Straggling." Although equation (40) gives the straggling about the mean pathlength, the width of the distribution should not be much broader about the mean range since the straggling is essentially a function of the number of electrons encountered while the multiple scattering is mainly the result of deflections by atomic nuclei.

The percent pathlength straggling has also been calculated and has been defined by

$$\text{Percent pathlength straggling} = 100 \frac{\sigma}{P(E_0)} \quad (41)$$

where  $P(E_0)$  is the value of the pathlength for a proton of kinetic energy  $E_0$ .

### 3. Multiple Coulomb Scattering

The probability is quite small that a proton will undergo a complete reversal of direction in losing energy in other than inelastic nuclear interactions. Angular deflections resulting from the multiple scattering of protons usually deviate the incident protons only slightly from the original direction. For this reason, the relationship between proton pathlength and range can be reasonably well defined.

In coulomb scattering processes involving only a negligible energy loss, multiple scattering depends strongly on the product of the proton momentum and velocity. To a first approximation, the multiple scattering of protons can be represented by a gaussian distribution with a nonsymmetrical tail to account for the infrequent occurrence of large angle scattering.

It is generally more useful to consider the projection of the total scattering angle onto a plane which is defined by the original trajectory and angle of incidence, rather than the total scattering angle itself. Furthermore, the average value of the projected angle usually has only a minor dependence on the occurrence of large angle scattering.

Although the multiple scattering calculations have been performed for an unbounded medium, they can be applied to any case where the loss of protons out of the sides of an absorber is negligible compared to the number transmitted in the forward direction. Many of the pertinent publications concerning the multiple scattering of protons are given by references 82 through 112.

Lewis (Ref. 88) has shown that the average value of the cosine of the mean scattering angle can be written as

$$\langle \cos \theta \rangle \left| \frac{E_0}{E} \right| = \exp \left[ - \int_E^{E_0} K_1 \frac{1}{\rho} \frac{dE}{dX} \right] \quad (42)$$

This expression must be substituted into equation (39) and integrated over the entire pathlength of the particle which entered the absorber with an initial kinetic energy  $E_0$ , and has now been degraded to energy  $E$ .

The  $K_1$  term in the exponent can be represented by

$$K_1 = 2\pi N \int_0^\pi \sigma(\theta, E) \sin\theta (1-\cos\theta) d\theta \quad (43)$$

In terms of simplicity, the screened Rutherford and McKinley-Feshbach cross sections are straightforward to use. Both have the advantage that they can be analytically integrated over the scattering angle to give the total scattering cross section. Although the Rutherford cross section is quantum mechanically correct, except for proton-proton scattering where the particles are identical, it is not truly relativistic. It has been extended for use at high velocities by insertion of the correct relativistic terms for the momentum, energy, and velocity in place of the classical relationships. Although these approximations improve the high-energy validity, they must be considered as only first-order corrections.

The McKinley-Feshbach cross section is strictly valid only for very low atomic number elements and for very high velocity particles; however, it approaches the Rutherford cross section in the classical limit. For this reason it has been employed for hydrogen and helium over the entire energy range, although minor discrepancies are apparent at energies on the order of 1 Mev or less.

The screened Rutherford cross section is (Ref. 97)

$$2\pi N\sigma(E, \theta) = \frac{z^2 Z^2}{A} \frac{2\pi e^4 N (1-\beta^2)}{M_T^2 c^4 \beta^4 (1+2\eta-\cos\theta)^2} \quad Z \geq 3 \quad (44)$$

The McKinley-Feshbach cross section is (Ref 103)

$$2\pi N\sigma(E, \theta) = \frac{z^2 Z^2}{A} \frac{2\pi e^4 N (1-\beta^2)}{M_T^2 c^4 \beta^4} \left[ \frac{1}{(1+2\eta-\cos\theta)^2} + \frac{\pi\alpha\beta}{\sqrt{2}(1-\cos\theta)^{3/2}} - \frac{\beta^2 + \pi\alpha\beta}{2(1-\cos\theta)} \right] \quad Z \leq 2 \quad (45)$$

where

$$\alpha = zZ \frac{e^2}{\hbar c} \quad (46)$$

And where  $M_r$  is the reduced mass of the proton in the scattering system and has been represented in the computations by

$$M_r = \frac{M}{(1+M/A)} \quad (47)$$

where  $M$  is the proton mass and  $A$  is the atomic weight of the scattering atom. If the reduced mass is simply set equal to the proton mass, a significant difference results for elements having very low atomic numbers, although this difference diminishes rapidly with increasing atomic weight. This is presented in table V.

Table V

DIFFERENCES IN THE PERCENT MULTIPLE SCATTERING RESULTING  
FROM USE OF THE PROTON MASS COMPARED TO THE REDUCED PROTON MASS

Element	Atomic number	10 Mev		100 Mev		1000 Mev	
		Reduced proton mass	Proton mass only	Reduced proton mass	Proton mass only	Reduced proton mass	Proton mass only
Hydrogen	1	0.085	0.021	0.072	0.017	0.062	0.015
Beryllium	4	0.115	0.092	0.095	0.077	0.083	0.067
Aluminum	13	0.350	0.328	0.277	0.258	0.248	0.231
Copper	29	0.803	0.780	0.603	0.589	0.543	0.529
Gold	79	2.37	2.33	1.66	1.64	1.48	1.44

The quantity  $\eta$  is a screening factor which is independent of the scattering angle, and has been given by Molière as (Ref. 106)

$$\eta = \frac{1}{4} \chi_0^2 \left[ 1.13 + 3.76 \alpha^2 / \beta^2 \right] \quad (48)$$

Nigam et al. (Refs. 104, 105) have performed a detailed evaluation of the screening parameter in the second Born approximation and have obtained a more consistent expression for the screening factor

$$\eta = \frac{1}{4} \chi_0^2 \left[ 1 - 2u \left\{ \frac{1 - \beta^2}{\beta} \ln \chi_0 + \frac{0.231}{\beta} + 1.448\beta \right\} \right]^2 \quad (49)$$

This expression has been used in the calculations instead of the relationship given by Molière.

The quantity  $\chi_0$  in the above expressions is defined by

$$\chi_0 = \mu \left[ \frac{(m/M)}{pc} \right] \left[ \frac{Z^{1/3}}{2 \left( \frac{3\pi}{4} \right)^{2/3}} \right] \left[ \frac{e^2}{\hbar c} \right] \quad (50)$$

where  $p$  is the relativistic momentum of the proton. The quantity  $\mu$  is indirectly

related to that of 1.13 in the theory of Molière and has been calculated by Mott (Ref. 107) to be 1.12. His value has been used throughout. The quantity  $\mu$  should be set equal to unity for calculations using the Molière theory. The coefficient 1.13 in equation (48) results from Molière's use of three exponentials to represent the Thomas-Fermi potential. Nigam et al. have obtained 1.00 for this because they used one exponential to represent the screened atomic potential. Calculations have been performed using both screening factors, and the differences are summarized in table VI.

Table VI

COMPARISON OF THE PERCENTAGE MULTIPLE SCATTERING OBTAINED  
THROUGH USE OF THE NIGAM AND MOLIÈRE SCREENING FACTOR  
USING THE REDUCED PROTON MASS

Element	Atomic number	10 Mev		100 Mev		1000 Mev	
		Nigam	Molière	Nigam	Molière	Nigam	Molière
Hydrogen	1	0.085	0.093	0.072	0.075	0.062	0.063
Beryllium	4	0.115	0.141	0.095	0.105	0.083	0.086
Aluminum	13	0.350	0.469	0.277	0.332	0.248	0.263
Copper	29	0.803	1.14	0.603	0.765	0.543	0.596
Silver	47	1.33	1.95	0.969	1.27	0.874	0.978
Gold	79	2.37	3.63	1.66	2.23	1.48	1.68
Uranium	92	2.72	4.21	1.95	2.63	1.73	1.98

There is a noticeable difference between the results obtained from the two multiple scattering theories. The difference is most pronounced at low energies in high atomic number materials. There are some experimental proton data for low energy protons in silver and gold which are of very high accuracy (Ref. 36). The experimental error of this data is less than 0.2 percent. When the Nigam theory is used, the results are within this experimental error. The Molière results are outside the possible error by approximately 1 percent.

Substitution of the Rutherford and McKinley-Feshbach cross sections into equation (43) and integrating over the scattering angle yields the following expressions for  $K_1$ , respectively:

$$K_1 = \frac{2\pi e^4 N_o}{M^2 c^4} \frac{z^2 Z^2}{A} \left[ \frac{T+1}{T(T+2)} \right]^2 \left[ \ln \left( 1 + \frac{1}{\eta} \right) - \frac{1}{1+\eta} \right] \quad Z \geq 3 \quad (51)$$

$$K_1 = \frac{2\pi e^4 N_o}{M^2 c^4} \frac{z^2 Z^2}{A} \left[ \frac{T+1}{T(T+2)} \right]^2 \left[ \ln \left( 1 + \frac{1}{\eta} \right) - \frac{1}{1+\eta} - \beta^2 + \pi \alpha \beta \right] \quad Z \leq 2 \quad (52)$$

where  $T$  is the kinetic energy of the incident proton in units of the proton rest mass

$$T = \frac{E}{Mc^2} \quad (53)$$

The procedure described above has been used to obtain the proton range which has been printed in the data tables under the heading "Proton Range." The percentage multiple scattering has also been tabulated since it is a useful way of expressing the results of the multiple scattering calculations.

$$\text{Percent multiple scattering} = 100 \frac{P(E_0) - R(E_0)}{P(E_0)} \quad (54)$$

where  $P(E_0)$  and  $R(E_0)$  are the pathlength and range, respectively, of protons having an initial energy  $E_0$ .

#### 4. The Number Distance Expression, Bragg Ionization Curve, and Extrapolated Pathlength

Most experimental measurements do not evaluate the mean pathlength or range directly. Variations of three techniques are commonly employed to obtain experimental proton range data. The first two result in range measurements, while the third actually gives the pathlength. In the first approach, a Faraday cup or similar device is used to determine the total number of protons which have passed through an absorber. The second employs a thin-walled ionization chamber to record the "Bragg ionization" of protons which have lost a large amount of kinetic energy in a given thickness of degrader. Nuclear emulsions have been used extensively and yield direct measurements of the pathlength and straggling because the particle tracks are visible. The results of these methods can then be used to determine the mean and extrapolated range and pathlength.

It is of interest to know the relationships between the number-distance curve, the Bragg curve, and the extrapolated pathlength. Approximate values for these quantities may be obtained in a straightforward manner under the following assumptions: (1) that the straggling distribution is exactly gaussian, (2) is not influenced by multiple scattering, and (3) the probability of inelastic nuclear interactions is negligible. These assumptions lead to the differential distribution of the number of protons which are distributed about the mean pathlength, given by (Ref. 86)

$$F(X)dX = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{[X-P(E_0)]^2}{2\sigma^2}} dX \quad (55)$$

The distribution about the mean range can be found by replacing the pathlength by the range in the above expression.

The probability  $P(n \geq X)$  of finding  $n$  particles which have traveled a distance equal to or greater than  $X$  can be obtained from equation (55) by integration. The result is usually referred to as the fractional transmission or number distance expression.

$$P(n \geq X) = \int_X^{\infty} F(X) dX \quad (56)$$

The results obtained from equations (55) and (56) are compared with the experimental transmission data of Bloembergen and van Heerden (Ref. 37) in figures 9 and 10.

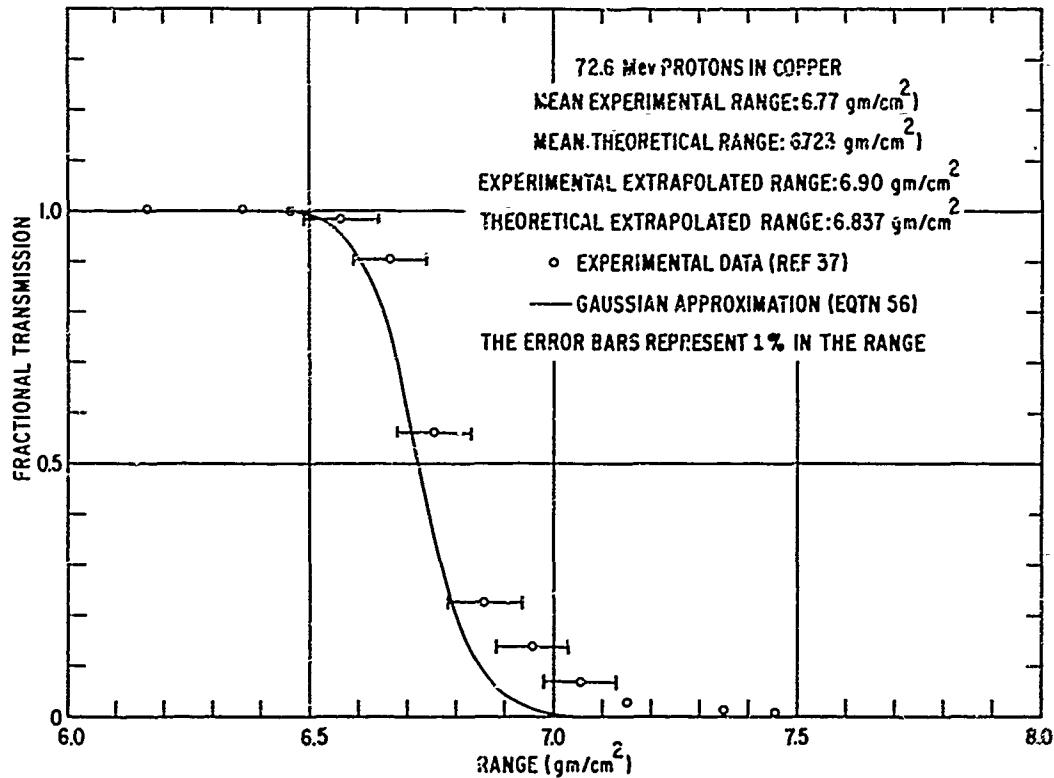


Figure 9. The Number Distance Curve for 72.6 Mev Protons in Copper Under the Gaussian Approximation

These relationships can also be used to obtain approximate values of the Bragg ionization curve. If proton straggling and scattering were truly negligible, the ionization as a function of pathlength for an initially monoenergetic beam of protons would be given simply by the differential energy loss at a given distance. However, there is a definite straggling of protons about the mean pathlength which causes a broadening of the width of the ionization curve. The shape of the Bragg curve can be obtained by folding the number distance



expression from equation (56) with the energy loss and pathlength relationships given by equations (3) and (36).

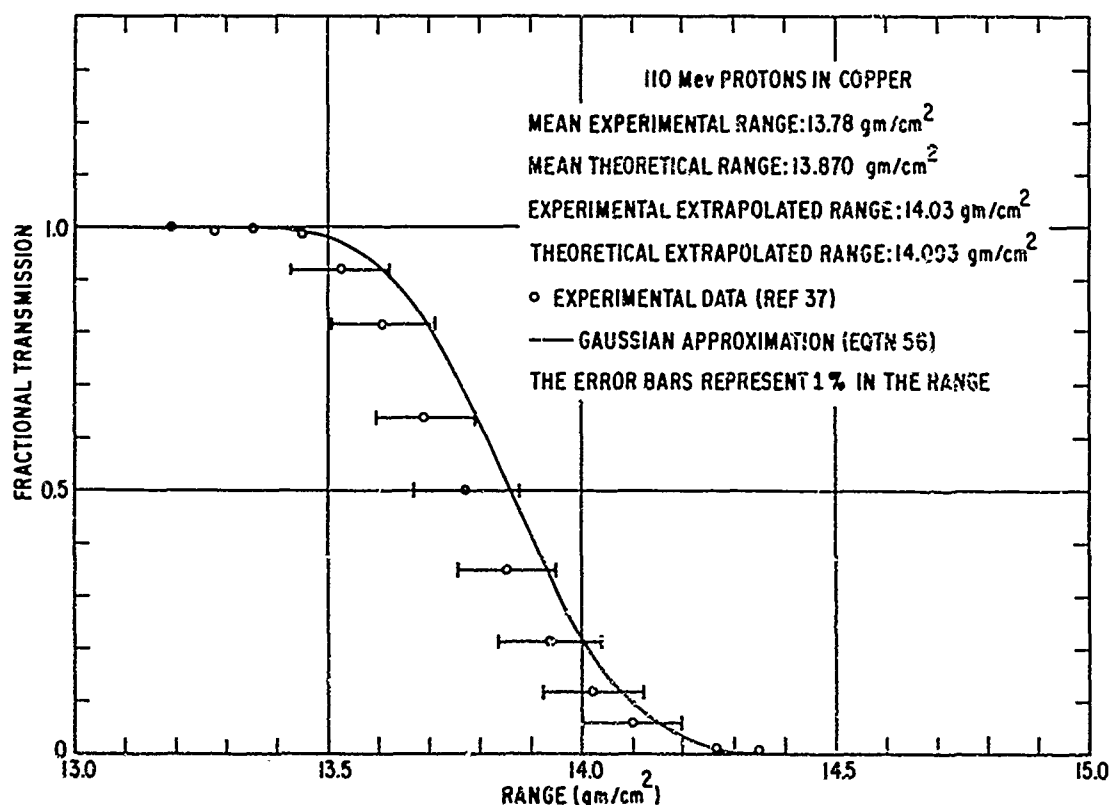


Figure 10. The Number Distance Curve for 110 Mev Protons in Copper Under the Gaussian Approximation

Further, the extrapolated pathlength can be obtained using the gaussian approximation if the mean pathlength is known.

$$P(E_o)_{\text{extr.}} = P(E_o)_{\text{mean}} + \sqrt{\frac{\pi}{2}} \sigma(E_o) \quad (57)$$

where  $P(E_o)_{\text{extr.}}$  is the extrapolated pathlength,  $P(R_o)_{\text{mean}}$  is the mean pathlength for protons of kinetic energy  $E_o$ , and  $\sigma(E_o)$  is the pathlength straggling given by equation (40). The extrapolated range can be obtained by replacing pathlength by range in equation (57).

If it is assumed that both the pathlength fluctuation and the multiple scattering can be represented by purely gaussian distributions, the total fluctuation in the proton range can be determined from the information available in the tables. The summation of several gaussian distributions in this manner will also yield a gaussian distribution.

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It must be emphasized that the gaussian approximation is accurate only to first order, but the symmetry of such a normal distribution greatly simplifies the theory. Should more accurate distributions be required, the reader is referred to the comprehensive tabulations of Seltzer and Berger (Refs. 108, 109).

#### SECTION IV

##### PROBABILITY OF INELASTIC NUCLEAR INTERACTIONS

In the determination of the proton pathlength and range, no consideration has been given to the possibility that an incident proton might undergo an inelastic nuclear interaction. The range and pathlength calculations do not apply to such protons. Thus, some information about the probability that such an interaction would occur over the entire pathlength of the particle would be of value. This has been calculated assuming an exponential interaction probability and has been presented in the tabulations under the heading "Probability of Inelastic Nuclear Interaction." The following relationship has been employed:

$$P(N) = 1 - \exp \left[ - N_0 \int_0^{P(E_0)} dX \frac{\sum_i r_i \sigma_i}{\sum_i r_i A_i} \right] \quad (58)$$

where

$P(N)$  is the probability of an inelastic nuclear interaction

$N_0$  is Avogadro's number

$P(E_0)$  is the total pathlength of the proton

$r_i$  is the number of atoms per molecule of the  $i$ 'th element in the compound

$\sigma_i$  is the total inelastic cross section of the  $i$ 'th element in barns

$A_i$  is the atomic weight of the  $i$ 'th element

The integral over the pathlength is required because the energy of the proton changes as it passes through the absorber. The inelastic cross section is dependent upon proton energy, thus the increment of pathlength and the cross section must both be included in the integral. The summations are required to determine the inelastic cross section for compounds and mixtures.

The above equation is most easily evaluated by making a change of variable from the pathlength to the energy loss at a given kinetic energy; this gives the following equation:

$$P(N) = 1 - \exp \left[ - N_0 \int_{0.1}^{E_0} \frac{dE}{\frac{1}{\rho} \frac{dE}{dX}} \frac{\sum_i r_i \sigma_i}{\sum_i r_i A_i} \right] \quad (59)$$

where  $E_0$  is the initial kinetic energy of the proton when it entered the material. The integral has been carried down to 0.1 Mev, even though the cross sections become negligibly small at energies somewhat above this.

The inelastic cross sections below 25 Mev have been obtained from the information published by Shapiro (Ref. 113), and by Pollock and Schrank (Ref. 114). The required cross sections between 25 and 400 Mev were obtained from the work of Bertini (Refs. 115, 116). Above 400 Mev, the transparency values listed by Metropolis et al. have been used (Refs. 117, 118). In those cases where data were not available, interpolations have been made between the nearest elements where such data were available. It should be noted that the inelastic cross section for protons incident upon hydrogen is zero until an energy of several hundred Mev is reached. The inelastic cross section for hydrogen was taken from figure 4a of reference 119.

For low energies the probability of formation of a compound nucleus predominates, and it has been assumed that this is the significant inelastic proton-nucleus interaction which takes place below 16 Mev. The inelastic scattering cross sections for aluminum, silver, and lead which have been used are representative and have been presented in figure 11.

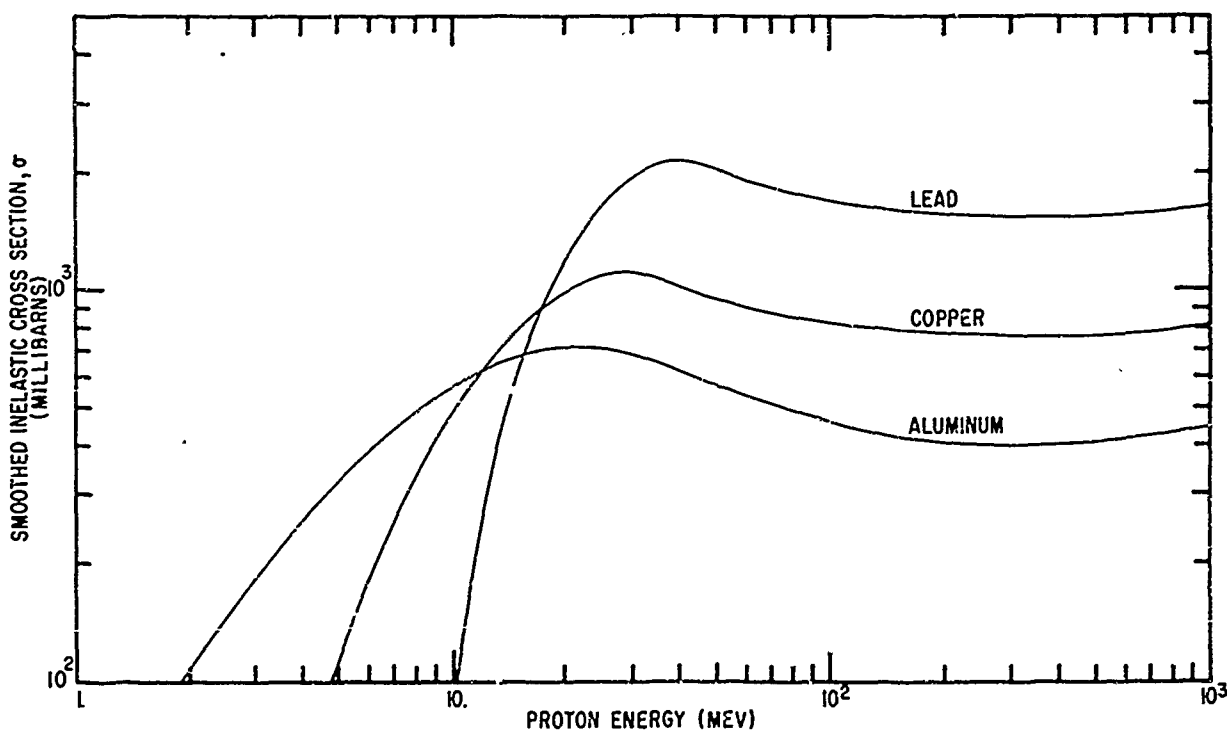


Figure 11. The Inelastic Scattering Cross Sections for Aluminum, Silver, and Lead Which Have Been Used to Determine the Probability of an Inelastic Nuclear Interaction

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The probability that a high-energy proton will undergo an inelastic nuclear collision is quite large. For this reason the high-energy calculations have not been extended beyond the minimum ionization point. Such high-energy calculations would be of little use, since range and pathlength values above 2 Bev are somewhat meaningless because of the predominance of nuclear interactions.

## SECTION V

### COMPARISON WITH SELECTED EXPERIMENTAL DATA

The tabulated values of the range and energy loss have been compared with the published experimental data for pertinent references listed in section VI. Comparisons for three representative elements (aluminum, copper, and gold) have been presented in tables VII, VIII, and IX and in figures 12, 13, and 14. These elements were selected because the data of several experimenters were available. Since the various experimental results are somewhat inconsistent, the use of several sets of data provides more insight into the accuracy of the calculations than does comparison with only one set of data. Excellent agreement between calculation and experiment has been obtained for most of the materials where the bulk of the data was internally consistent.

The measuring techniques used in each experiment also effect the error and final results, and consequently a certain amount of the inconsistency appearing in the experimental data is probably a result of experimental technique.

The reader is strongly urged to review the detailed experimental and theoretical comparisons which have been presented in the appendix. The experimental energy loss and range have been compared in considerable detail with the tabulations presented in this and other similar reports (Refs. 1 through 9). The percent difference from the experimental data of each report have been presented along with the experimental error, mean error, and relative standard deviations of the calculations for each set of experimental data. The experimental data of a given experimenter have been presented in the order of increasing atomic number.

The energy loss and range values tabulated in this report are usually within 1 percent of the experimental data or the error estimates of the experimenter, whichever is larger.

Table VII

A COMPARISON OF EXPERIMENTAL ENERGY LOSS IN Mev/gm/cm<sup>2</sup> WITH  
THE TABULATIONS OF THIS REPORT FOR ALUMINUM

Proton energy	This report	Nielsen Ref. 130	Kahn Ref. 54	Warshaw Ref. 20	Wilcox Ref. 57	Summary of Bichsel Ref. 4
0.10	418.06			416.0	458	420.0
0.15	371.51			366.0	405	380.0
0.20	344.46			333.5	366	343.0
0.25	323.66		314.5		340	327.0
0.30	305.58		297.0	295.0	311	310.0
0.35	289.78		283.0			293.0
0.40	276.04		271.0	275.0		279.0
0.45	263.68		260.0			265.0
0.50	251.99		250.0			252.0
0.55	240.68		241.0			241.0
0.60	229.99		233.0			230.0
0.65	220.98		223.5			
0.70	212.01		217.0			212.0
0.75	204.50		210.0			
0.80	196.99		202.5			197.0
0.85	191.25		196.0			
0.90	185.51		189.5			185.0
0.95	179.77		183.0			
1.0	174.02	172.4	177.0			173.0
1.1	163.92		166.5			163.0
1.2	155.48		157.5			155.0
1.3	147.81		150.5			147.0
1.4	140.88					140.0
1.5	134.63	133.3				134.3
1.6	128.96					129.0
1.8	119.11					119.0
2.0	110.82	109.9				110.7
2.5	94.806	94.2				94.7
3.0	83.278	82.8				83.2
3.5	74.522	74.2				74.5
4.0	67.606	67.4				67.6
4.5	61.992	62.0				62.0
5.0	57.335	57.4				57.3
5.5	53.402					53.4
6.0	50.135					50.0

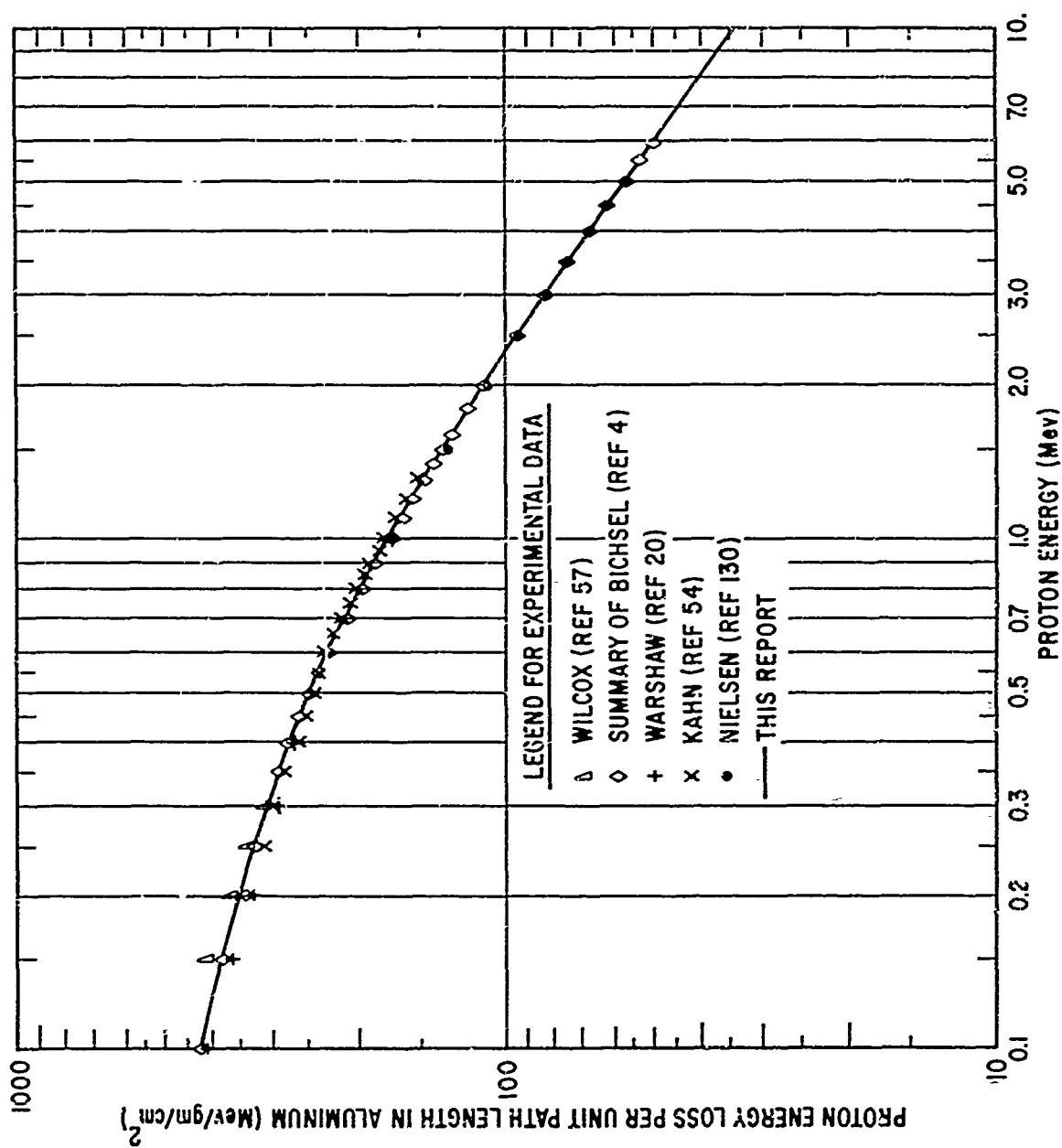


Figure 12: A Comparison of the Experimental and Calculated Energy Loss for Aluminum



Table VIII

A COMPARISON OF EXPERIMENTAL ENERGY LOSS IN Mev/gm/cm<sup>2</sup> WITH  
THE TABULATIONS OF THIS REPORT FOR COPPER

Proton energy	This report	Bader et al. Ref. 42	Green et al. Ref. 41	Nielsen Ref. 130	Richsel, Summary of Rept. #3 Richsel Ref. 21 Ref. 4	Warshaw Ref. 20	Kahn Ref. 54
0.1	225.66	227.5			228	223.5	
0.15	227.21	227.5			228	228.0	
0.2	221.45	217.0			221	222.0	
0.25	211.34	205.7			211		212.0
0.3	200.95	199.0			201	201.0	200.0
0.35	191.12	191.5			192		189.5
0.4	182.31	181.8	179		183	183.0	180.5
0.45	174.49	178.2	172		175		172.5
0.5	167.45	171.6	165		168		166.0
0.55	160.94	165.8	158		161		160.0
0.6	154.86	160.1	152		155		154.0
0.65	149.45		147				148.5
0.7	144.04		142		144		144.0
0.75	139.65		137				140.0
0.8	135.27		133		135		136.0
0.85	131.85		128				132.0
0.9	128.44		125		128		128.7
0.95	125.02		122				126.0
1.0	121.60		119		121		122.0
1.1	115.15				114		117.0
1.2	109.47				109		112.5
1.3	104.40				104		109.0
1.4	99.834				99		
1.5	95.778			95.0	95		
1.6	92.062				94.5		
1.8	85.765				88.5		
2.0	80.408			80.0	83.5		
2.5	69.921			69.5	74.0		
3.0	62.325			62.2			
3.5	56.384			56.5			
4.0	51.618			51.7			
4.5	47.688			47.5			
5.0	44.381				44		
5.5	41.553				41		
6.0	39.105				39		
12.0	23.738				23.87		
20.0	16.236				16.22		
29.0	12.254				12.15		
267.0	2.5731				2.61		
300.0	2.4138				2.422		
615.0	1.7616				1.772		
651.0	1.7292				1.74		

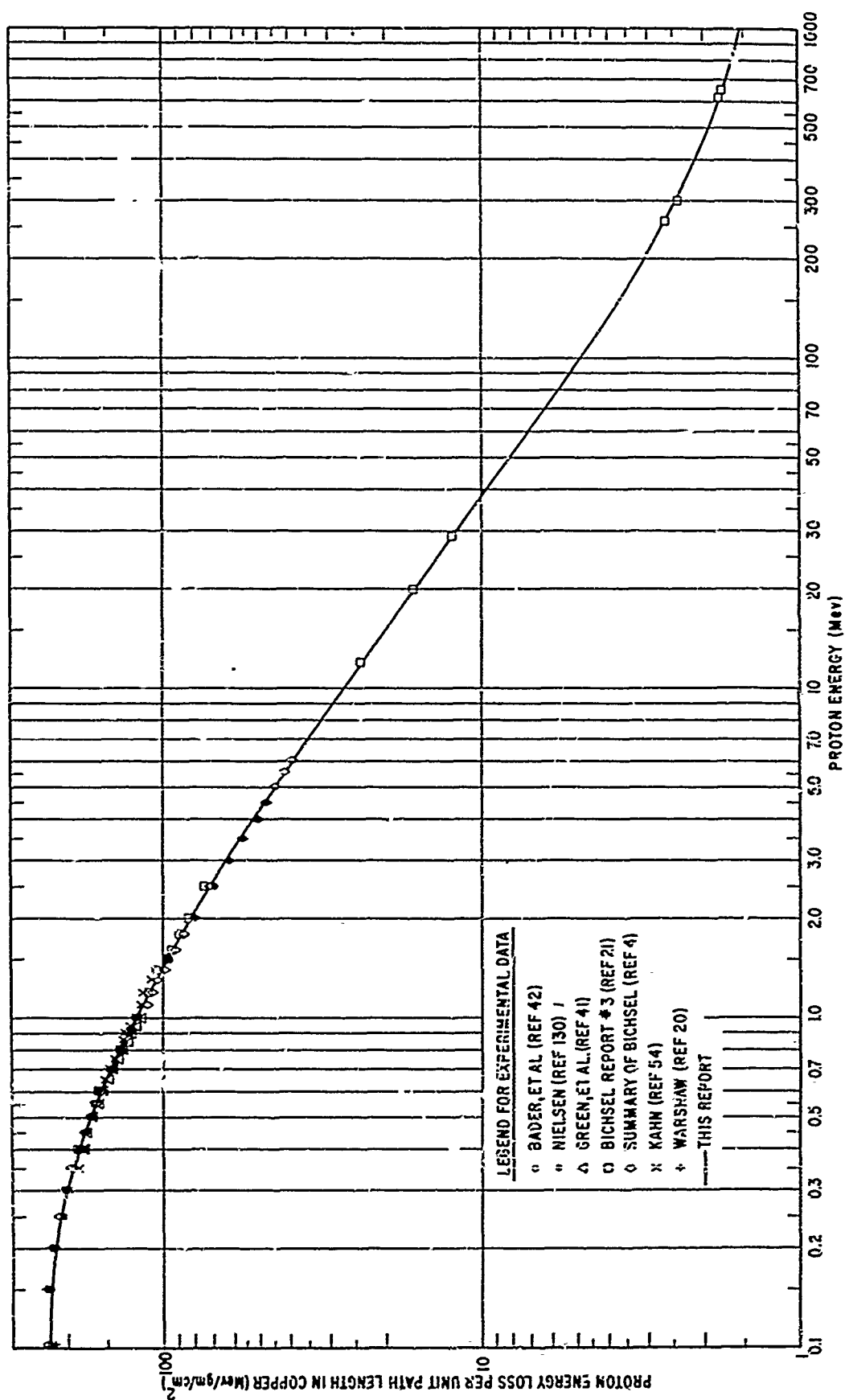


Figure 13. A Comparison of the Experimental and Calculated Energy Loss for Copper

Table IX

A COMPARISON OF EXPERIMENTAL ENERGY LOSS IN Mev/gm/cm<sup>2</sup> WITH  
THE TABULATIONS OF THIS REPORT FOR GOLD

Proton energy	This report	Bader et al.* Ref. 42	Nielsen Ref. 130	Kahn Ref. 54	Green et al. Ref. 41	Bichsel, Summary of Rept. #3 Bichsel Ref. 21 Ref. 4	Wilcox Ref. 57
0.10	104.91	105.5		87.0		105.0	84
0.15	116.33	115.8		90.0		116.0	87
0.20	118.68	118.9		88.5		119.0	85
0.25	115.79	115.8		84.5		116.0	81
0.30	110.35	110.7		80.5		110.0	77
0.35	104.08	103.9		77.2		104.0	73
0.40	98.012	97.22		74.5	96	98.0	66
0.45	92.637	91.71		72.0	92	93.0	
0.50	88.077	86.82		69.5	88	88.0	
0.55	84.229	83.46		67.5	84	84.0	
0.60	80.891	80.40		66.0	80	81.0	
0.65	77.942			64.5	78		
0.70	74.994			63.5	75	75.0	
0.75	72.498			62.0	73		
0.80	70.003			60.2	71	71.0	
0.85	68.403			59.0	69		
0.90	66.803			58.5	67	66.0	
0.95	65.202			58.0	65		
1.0	63.601			57.0	64	65.0	63.0
1.1	61.270			55.2			59.6
1.2	59.084			54.0		60.0	57.0
1.3	57.073						54.3
1.4	55.155					56.0	52.5
1.5	53.544						50.5
1.6	52.023					52.0	49.0
1.8	49.237					49.0	46.8
2.0	46.761		44.0			46.8	44.0
2.5	41.651		40.0			41.5	39.8
3.0	37.679		36.5			38.0	36.4
3.5	34.495		34.0			34.0	33.9
4.0	31.882		32.0			31.4	31.6
4.5	29.707		29.5			29.4	29.6
5.0	27.849					27.8	27.7
5.5	26.234						26.2
6.0	24.861						24.8
12.0	15.922					16.23	
20.0	11.240					11.38	
29.0	8.6618					8.61	

\*These are not the units originally used by this experimenter.

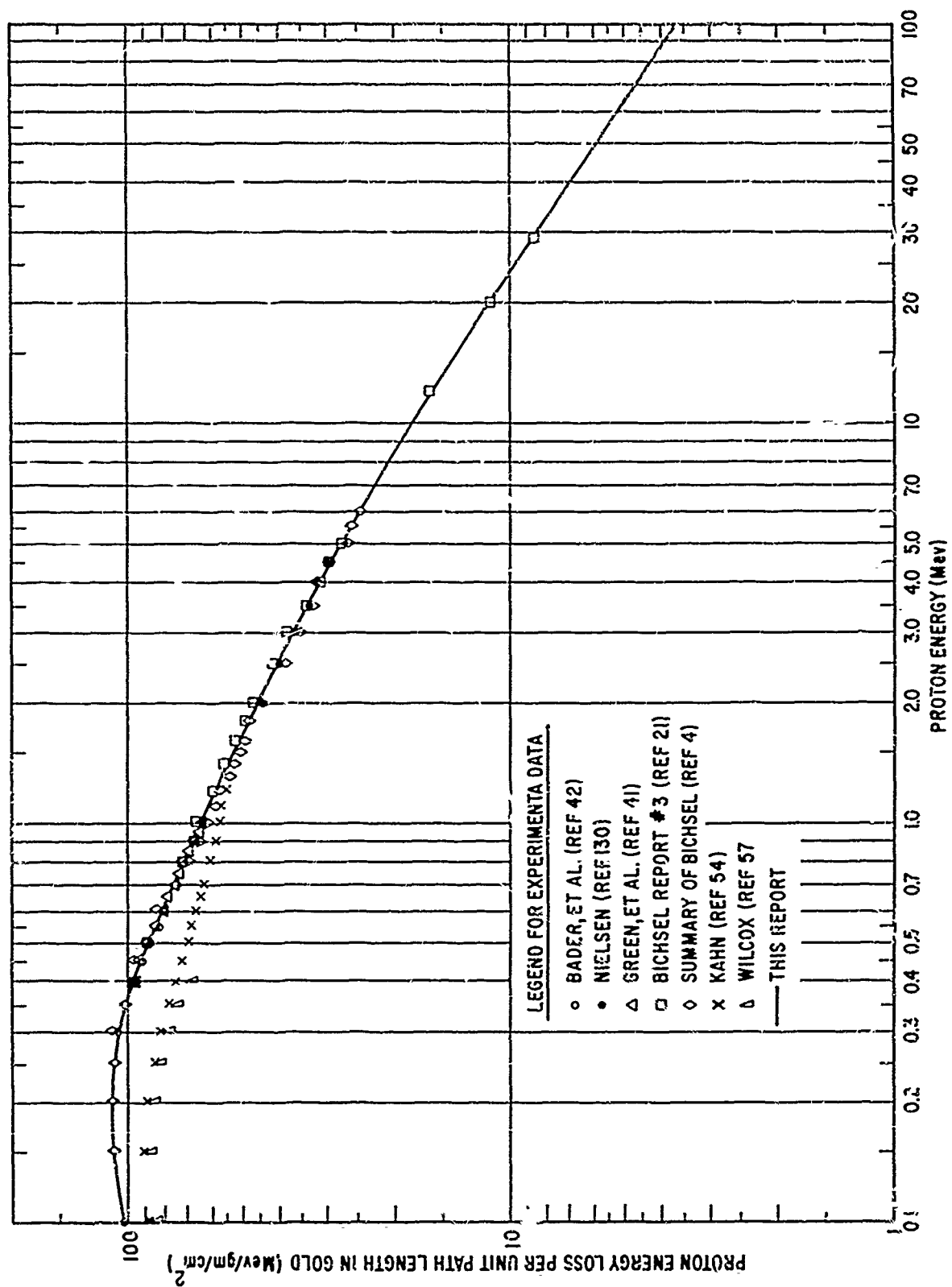


Figure 14. A Comparison of the Experimental and Calculated Energy Loss for Gold

## SECTION VI

### COMMENTS PERTINENT TO DATA PRESENTATION AND FORMAT

The physical constants which have been used were taken exclusively from the recent recommendations by Cohen and DuMond in reference 120. The system of atomic weights based on carbon 12 have been used throughout, and were obtained from reference 121.

The data have been divided into two groups. The elements are listed alphabetically in the first group, and compounds and mixtures are listed alphabetically under their most common name in the second group.

Pertinent information about each material has been listed at the top of the first page. This includes the adjusted ionization potential, the number of atoms per molecule, the percent by weight of each element in the compound or mixture, the atomic number, the atomic weight, and the density of the material. At the bottom of the last page the electron density, effective ionization potential, the energy at which minimum ionization occurs, and the minimum ionization have been tabulated.

All results have been presented using both density-dependent and independent unit systems. When grams per square centimeter or milligrams per square centimeter have been used as the unit of thickness, the calculations are independent of the density, except for the very small perturbation from the polarization effect term. However, when millimeters, centimeters, or meters were used, the numerical values are directly dependent upon the density which has been selected, and the tabulations are strictly correct only for that density.

When the material was a gas, meters and kilovolts per centimeter were used. In other cases, millimeters have been used on the first page and centimeters were used on all succeeding pages. The units which have been used for a given page have always been clearly listed at the top of each column.

The results have been presented using a fine energy grid to minimize the need for interpolation. Since the low-energy region is of interest to many groups, emphasis has been placed on careful presentation of the data in this area.

The electron density of a material is a useful quantity and has also been calculated. The following relation was used:

$$\text{Electron density} = \frac{\sum_i Z_i N_i r_i}{\sum_i A_i r_i} \quad (\text{electrons/gram}) \quad (60)$$

where the summation extends over all of the atoms within the molecule. The electron density in the above units appears at the bottom of the last page for each material. An E format has been used to represent these results. The E printed immediately after the digits indicates the power to which the factor of ten following the digits must be raised, thus:

$$1.234E\ 23 = 1.234 \times 10^{23}$$

When the material was a mixture and not a true chemical compound, the percent by weight of each element in the compound has been converted to a ratio which would be equivalent to the number of atoms per molecule had the mixture actually been a compound.

The unit of square centimeters has been consistently printed with the power on the same line as the alphabetical characters, as is indicated below:

$$\text{cm}^2 = \text{cm}2$$

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## APPENDIX

This appendix contains the results from a selective survey of energy loss, range, pathlength, and straggling data for protons having energies greater than 100 kilovolts.

This collected experimental data has been compared to the calculations of this report, as well as with the tabulations of references 1 through 9. Extensive comparisons of the energy losses from all of the aforementioned reports have been made. Pathlength comparisons have been made only for emulsion, where proton track lengths may be observed directly. Since only the tables of Williamson and Boujot (Ref. 9) calculate the range, their results have been compared with experimental range data. All of the other reports in references 1 through 9 calculate only the pathlength, which must be corrected for multiple scattering effects in order that a valid comparison be made.

The comparisons of the experimental and calculated ranges also provide a certain amount of verification of the multiple scattering technique which has been used.

Error estimates have been displayed with the data wherever they were explicitly stated or could be readily estimated from the information given by the experimenter.



COMPARISON OF EXPERIMENTAL AND CALCULATED PROTON MASS  
STOPPING POWER RELATIVE TO ALUMINUM

Element	19.8 Mev			20.6 Mev			28.7 Mev			340 Mev		
	Experi- mental	This report	Percent differ- ence	Experi- mental	This report	Percent differ- ence	Experi- mental	This report	Percent differ- ence	Experi- mental	This report	Percent differ- ence
2	Ref. 30			Ref. 124			Ref. 125			Ref. 28		
H										2.634	2.614	-0.76
Li										1.062	1.056	-0.56
Re	1.073	1.090	1.58				1.089	1.079	-0.92	1.024	1.033	0.87
C										1.124	1.136	1.06
Al	1.000	1.000	0.00	1.000	1.000	0.00	1.000	1.000	0.00	1.000	1.000	0.00
Ca	1.008	0.9795	-2.82									
Ti	0.838	0.8884	0.04				0.8969	0.8939	-0.33			
V	0.860	0.8672	0.84				0.8605	0.8722	1.36			
Fe	0.856	0.8666	1.24							0.906	0.9046	-0.15
Co							0.8501	0.8489	-0.14			
Ni	0.863	0.8628	-0.02	0.859	0.8642	0.60	0.8691	0.8724	0.38			
Cm	0.821	0.8208		0.836	0.8222	-1.65	0.8233	0.8304	0.86	0.975	0.8682	-0.78
Zn	0.819	0.8190	0.00									
Ag	0.715	0.7124	-0.36	0.717	0.7144	-0.36	0.7164	0.7272	1.51	0.789	0.7864	-0.33
Sn	0.680	0.6813	0.19							0.751	0.7560	0.66
Ta	0.597	0.5844	-2.11	0.607	0.5867	-3.34	0.5981	0.6044	1.05			
W	0.590	0.5805	-1.61				0.5866	0.6005	2.37	0.680	0.6786	-0.21
Pt	0.576	0.5682	-1.35	0.590	0.5705	-3.30						
Au	0.576	0.5679	-1.41	0.588	0.5702	-3.02	0.5838	0.5866	0.48	0.660	0.6567	-0.50
Pb	0.556	0.5543	-0.30							0.630	0.6301	0.02
U												

The error of Ref. 30 is from 0.3 to 2 percent.

The error of Ref. 124 is from 0.5 to 2 percent.

The error of Ref. 125 is from 0.2 to 1 percent.

The error of Ref. 28 is about 5 percent for hydrogen and 1 percent for the other data.

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BROLLEY AND RIBE (Ref. 63)

Material	E(Mev)	Experimental Data	Experimental Accuracy (percent)	This Report	Percent Difference
Hydrogen	4.44	202.0	2.1	204.61	+1.3
Helium	4.45	88.02	2.3	88.634	+0.7
Nitrogen	4.42	75.68	2.3	75.862	+0.2
Oxygen	4.40	71.82	2.1	75.654	-5.3
Neon	4.43	68.34	2.2	67.243	-1.6
Argon	4.43	56.09	2.2	54.855	-2.2
Krypton	4.41	43.84	2.5	43.142	-1.6
Xenon	4.44	36.97	2.1	35.099	-5.1
Air	4.42	74.53	2.2	75.217	-0.9
Methane	4.43	109.2	2.0	109.60	+0.4
Carbon dioxide	4.43	75.68	2.1	74.672	-1.3

THIS COMPARISON IS FOR MANGANESE

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF GREEN, COOPER, AND HARRIS (Ref. 41)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF
.4000	218.0	221.75 1.72	
.4500	206.0	206.86 .417	
.5000	196.0	194.78 -.622	190.60 -2.76
.5500	186.0	185.08 -.495	
.6000	177.0	176.73 -.153	174.36 -1.49
.6500	169.0	168.55 -.266	
.7000	162.0	160.11 -1.17	160.89 -.685
.7500	156.0	152.89 -1.99	
.8000	151.0	151.71 .473	149.50 -.993
.8500	147.0	147.55 .374	
.9000	143.0	143.39 .273	139.75 -2.27
.9500	140.0	139.23 -.550	
1.000	136.0	135.06 -.691	131.26 -3.49

The mean percentage deviation of the tabulated data of this report from the above experimental data is -0.206 percent.

The percent relative standard deviation of the tabulated data of this report from the above experimental data is 0.895 percent.

The experimental error is approximately 2.5 percent.

## THIS COMPARISON IS FOR COPPER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF GREEN, COOPER, AND HARRIS (REF 41)

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF	HILL, ET AL*	PRCT DIFF
.4000	179.0	182.31	1.85		
.4500	172.0	174.49	1.45		
.5000	165.0	167.45	1.48	177.41	7.52
.5500	158.0	160.94	1.86		
.6000	152.0	154.86	1.88	164.11	7.97
.6500	147.0	149.45	1.67		
.7000	142.0	144.04	1.44	152.51	7.40
.7500	137.0	139.65	1.93		
.8000	133.0	135.27	1.71	142.46	7.11
.8500	128.0	131.85	3.01		
.9000	125.0	128.44	2.75	133.77	7.02
.9500	122.0	125.02	2.48		
1.000	119.0	121.60	2.18	126.16	6.02

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.98 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.03 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 2.5 PERCENT

## THIS COMPARISON IS FOR TIN

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF GREEN, COOPER, AND HARRIS (REF 41)

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF	HILL, ET AL*	PRCT DIFF
.4000	142.0	145.09	2.18		
.4500	135.0	135.61	.452		
.5000	128.0	127.69	-.242	129.40	1.09
.5500	122.0	121.10	-.738		
.6000	116.0	115.61	-.336	116.33	.284
.6500	111.0	110.98	-.018		
.7000	107.0	106.97	-.028	106.28	-.673
.7500	103.0	103.36	.350		
.8000	100.0	99.919	-.081	98.263	-1.74
.8500	97.00	97.088	.091		
.9000	94.00	94.257	.273	92.129	-1.99
.9500	91.00	91.426	.468		
1.000	89.00	88.591	-.460	87.392	-1.81

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .147 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .696 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 2.5 PERCENT

## THIS COMPARISON IS FOR GERMANIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF GREEN, COOPER, AND HARRIS (REF 41)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF
.4000	177.0	175.49 -.953	
.4500	168.0	166.76 -.738	
.5000	159.0	159.12 .075	162.75 2.36
.5500	153.0	152.58 -.275	
.6000	147.0	146.05 -.646	151.16 2.83
.6500	142.0	142.30 .211	
.7000	138.0	138.06 .043	141.17 2.30
.7500	133.0	133.89 .669	
.8000	130.0	129.32 -.523	132.38 1.83
.8500	126.0	124.41 -1.26	
.9000	123.0	119.51 -2.84	124.64 1.33
.9500	119.0	114.60 -3.70	
1.000	116.0	109.69 -5.44	117.82 1.57

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -1.17 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.07 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 2.5 PERCENT

## THIS COMPARISON IS FOR SELENIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF GREEN, COOPER, AND HARRIS (REF 41)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF
.4000	168.0	168.14 .083	
.4500	160.0	159.83 -.106	
.5000	154.0	153.11 -.578	147.30 -4.35
.5500	148.0	147.61 -.264	
.6000	143.0	142.70 -.210	137.91 -3.56
.6500	138.0	138.76 .551	
.7000	134.0	134.66 .493	129.67 -3.23
.7500	130.0	130.29 .223	
.8000	126.0	125.27 -.579	122.36 -2.89
.8500	122.0	120.80 -.984	
.9000	120.0	116.33 -3.06	115.75 -3.54
.9500	117.0	111.85 -4.40	
1.000	115.0	107.37 -6.63	109.83 -4.50

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -1.19 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.40 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR SILVER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF GREEN, COOPER, AND HARRIS (REF 41)

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.4000	150.0	150.62 .413	
.4500	142.0	142.09 .063	
.5000	135.0	134.57 -.319	128.05 -5.15
.5500	128.0	127.81 -.148	
.6000	121.0	121.29 .240	115.92 -4.20
.6500	116.0	115.97 -.026	
.7000	111.0	110.90 -.090	106.53 -4.03
.7500	107.0	106.57 -.402	
.8000	103.0	103.26 .252	99.929 -2.98
.8500	101.0	100.60 -.396	
.9000	98.00	97.942 -.059	94.536 -3.53
.9500	96.00	95.283 -.747	
1.000	94.00	92.620 -1.47	89.902 -4.36

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.207 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .516 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 2.5 PERCENT

## THIS COMPARISON IS FOR ANTIMONY

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF GREEN, COOPER, AND HARRIS (REF 41)

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.4000	146.0	146.54 .370	
.4500	138.0	138.57 .413	
.5000	132.0	131.42 -.439	123.18 -6.68
.5500	125.0	124.86 -.113	
.6000	119.0	118.77 -.193	110.96 -6.76
.6500	113.0	113.17 .150	
.7000	108.0	108.16 .148	101.86 -5.69
.7500	104.0	103.97 -.029	
.8000	101.0	100.95 -.050	94.627 -6.31
.8500	98.00	97.092 -.927	
.9000	96.00	93.234 -2.88	88.589 -7.72
.9500	93.00	89.376 -3.90	
1.000	91.00	85.514 -6.03	83.956 -7.74

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -1.04 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.17 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 2.5 PERCENT

## THIS COMPARISON IS FOR GCLD

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF GREEN, COOPER, AND HARRIS (REF 41)

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.4000	96.00	98.012 2.10	
.4500	92.00	92.637 .692	
.5000	88.00	88.077 .088	90.926 3.32
.5500	84.00	84.229 .273	
.6000	80.00	80.391 1.11	65.129 6.41
.6500	78.00	77.942 -.074	
.7000	75.00	74.994 -.008	79.976 6.63
.7500	73.00	72.498 -.688	
.8000	71.00	70.003 -1.40	75.985 7.02
.8500	69.00	68.403 -.865	
.9000	67.00	66.803 -.294	71.871 7.27
.9500	65.00	65.202 .311	
1.000	64.00	63.601 -.623	68.348 6.79

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .047 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .876 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 2.5 PERCENT

## THIS COMPARISON IS FOR LEAD

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF GREEN, COOPER, AND HARRIS (REF 41)

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.4000	100.0	99.802 -.198	
.4500	95.00	94.678 -.339	
.5000	90.00	90.308 .342	86.467 -3.93
.5500	86.00	86.326 .379	
.6000	82.00	82.632 .771	80.110 -2.30
.6500	79.00	79.850 1.08	
.7000	75.00	77.074 2.77	75.076 .101
.7500	73.00	74.032 1.41	
.8000	70.00	70.991 1.42	71.496 2.14
.8500	68.00	69.015 1.49	
.9000	67.00	67.040 .060	67.596 .890
.9500	65.00	65.103 .158	
1.000	64.00	63.087 -1.43	64.369 .577

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .608 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.18 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 2.5 PERCENT

## THIS COMPARISON IS FOR BISMUTH

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF GREEN, COOPER, AND HARRIS (REF 41)

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.4000	104.0	100.06 -3.79	
.4500	99.00	94.927 -4.11	
.5000	94.00	90.545 -3.68	85.967 -8.55
.5500	90.00	86.554 -3.83	
.6000	86.00	82.849 -3.66	79.617 -7.42
.6500	82.00	80.060 -2.37	
.7000	79.00	77.276 -2.18	74.528 -5.66
.7500	75.00	74.226 -1.03	
.8000	73.00	71.177 -2.50	70.994 -2.75
.8500	70.00	69.176 -1.18	
.9000	69.00	67.176 -2.64	67.044 -2.83
.9500	67.00	65.171 -2.73	
1.000	66.00	63.165 -4.30	63.821 -3.30

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -2.92 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 3.10 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 2.5 PERCENT

## THIS COMPARISON IS FOR NEON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF CHILTON, COOPER, AND HARRIS (REF 64)

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*
		PRCT DIFF
.4220	310.0	311.70 .548
.4240	290.0	310.56 7.09
.5170	280.0	279.03 -1.346
.5190	269.0	278.44 3.51
.6380	236.0	238.72 1.15
.7300	217.0	227.24 4.72
.7330	217.0	226.67 4.46
.9290	186.0	199.40 7.20
.9300	191.0	199.28 4.34
.9380	175.0	192.60 10.1
.9920	188.0	192.26 2.27

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 4.09 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 5.08 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.5 PERCENT

## THIS COMPARISON IS FOR NITROGEN

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF CHILTON, COOPER AND HARRIS(REF 64)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF
.4080	400.0	394.65	-1.38
.4100	401.0	393.42	-1.39
.4540	371.0	376.43	1.46
.5020	362.0	378.88	4.66
.5030	351.0	343.92	-2.02
.5420	328.0	343.50	4.73
.6480	296.0	293.20	-.946
.7160	275.0	274.12	-.320
.7170	264.0	273.64	3.65
.7500	257.0	265.97	3.49
.8140	228.0	235.95	3.49
.9420	217.0	231.86	6.85
.9730	207.0	227.15	9.73
.9740	228.0	226.68	-.579
1.001	209.0	222.58	6.50

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.56 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 4.29 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR XENON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF CHILTON, COOPER AND HARRIS(REF 64)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF
.4370	121.0	136.38	12.7
.4410	121.0	135.73	12.2
.5360	111.0	122.68	10.5
.5380	115.0	121.91	6.01
.6790	93.00	106.04	14.0
.7480	87.00	102.01	17.3
.7500	93.00	101.61	9.26
.9430	78.00	85.668	9.83
.9690	77.00	83.426	8.35

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 11.1 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 11.6 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.5 PERCENT

THIS EXPERIMENTAL DATA DISAGREES STRONGLY WITH THAT OF REFS 4 AND 56



## THIS COMPARISON IS FOR NICKEL

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF CHILTON, COOPER AND HARRIS(REF 64)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF
.5270	172.0	176.68	2.72
.7040	149.0	151.54	1.70
.7130	150.0	149.35	-.433
.7390	143.0	146.56	2.49
.7410	142.0	146.32	3.04
.7550	145.0	145.04	.028
.7570	146.0	144.86	-.781
.9150	128.0	134.04	4.72
.9350	126.0	132.81	5.40
.9410	134.0	132.44	-1.16
.9490	126.0	131.95	3.09
.9510	132.0	131.82	-.136
.9770	129.0	130.22	.946
1.000	127.0	128.79	1.41
1.007	122.0	128.28	5.15
1.046	120.0	125.49	4.57
1.047	122.0	125.42	2.80
1.057	121.0	125.21	3.48

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.17 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.97 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR COPPER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF CHILTON, COOPER AND HARRIS(REF 64)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF
.4460	163.0	173.12	3.62
.5320	158.0	163.26	3.34
.6030	150.0	154.54	3.03
.7130	140.0	142.90	2.07
.7550	137.0	139.21	1.61
.8120	132.0	134.45	1.86
.9490	120.0	125.09	4.24
.9960	115.0	121.88	5.98
1.006	112.0	121.16	8.20
1.050	113.0	118.26	4.65

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 3.86 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 4.32 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 2.0 PERCENT

## THIS COMPARISON IS FOR ARGON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF CHILTON, COOPER AND HARRIS (REF 64)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF
.4210	225.0	243.56	8.25
.4760	224.0	226.69	1.20
.5190	215.0	215.39	.181
.5670	207.0	205.39	-.778
.6620	176.0	190.06	7.99
.7130	187.0	182.32	-2.50
.7780	176.0	173.85	-1.22
.9290	154.0	155.36	.883
.9320	155.0	154.99	-.006
.9710	154.0	150.27	-2.42
.9890	149.0	148.09	-.611

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .997 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 3.68 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.5 PERCENT

## THIS COMPARISON IS FOR KRYPTON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF CHILTON, COOPER AND HARRIS (REF 64)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF
.4200	163.0	155.09	-4.85
.5160	150.0	141.14	-5.91
.5270	154.0	139.84	-9.19
.6650	130.0	126.08	-3.02
.6750	129.0	122.93	-4.69
.7330	124.0	120.66	-2.69
.7430	122.0	119.97	-1.66
.9290	107.0	107.90	.841
.9410	107.0	107.54	.505
.9890	103.0	104.66	1.61

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -2.91 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 4.33 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR HYDROGEN

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF REYNOLDS, ET AL (REF 56)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT PRCT DIFF	HILL, ET AL PRCT DIFF
.1000	3484.	3480.7 -.095	
.1500	2808.	2807.7 -.011	
.2000	2330.	2330.8 .034	
.2500	1989.	1990.8 .090	
.3000	1729.	1743.1 .816	
.3500	1554.	1555.7 .109	
.4000	1404.	1407.2 .228	
.4500	1279.	1284.1 .399	
.5000	1177.	1179.7 .229	1180.1 .263
.5500	1087.	1091.2 .386	
.6000	1016.	1017.7 .167	1027.0 1.08

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .214 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .321 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR HELIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF REYNOLDS, ET AL (REF 56)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT PRCT DIFF	HILL, ET AL PRCT DIFF
.1000	1098.	1096.1 -.173	
.1500	958.4	954.64 -.392	
.2000	835.1	832.61 -.298	
.2500	738.8	736.13 -.361	
.3000	663.5	661.65 -.279	
.3500	603.4	602.87 -.088	
.4000	555.2	554.41 -.142	
.4500	514.6	513.14 -.284	
.5000	478.4	477.81 -.123	468.95 -1.98
.5500	449.9	447.86 -.453	
.6000	422.8	422.19 -.144	412.74 -2.38

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.249 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .275 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR CARBON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF REYNOLDS, ET AL (REF 56)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.1000	814.9	822.92 .984	
.1500	732.1	720.41 -1.60	
.2000	636.9	635.71 -.187	
.2500	565.6	566.14 .095	
.3000	511.5	509.25 -.440	
.3500	466.4	462.81 -.770	
.4000	428.2	424.35 -.782	
.4500	398.2	393.63 -1.15	
.5000	370.1	367.65 -.662	357.62 -3.37
.5500	348.5	345.65 -.818	
.6000	328.5	326.61 -.575	317.99 -3.20

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.536 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .838 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR OXYGEN

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF REYNOLDS, ET AL (REF 56)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.1000	646.4	669.76 3.61	
.1500	607.2	600.68 -1.07	
.2000	553.4	543.55 -1.78	
.2500	500.0	494.09 -1.18	
.3000	451.4	450.79 -.135	
.3500	414.4	413.32 -.261	
.4000	385.0	381.69 -.860	
.4500	355.8	355.72 -.022	
.5000	332.8	334.66 .559	322.73 -3.03
.5500	315.4	317.17 .561	
.6000	297.8	301.66 1.30	289.34 -2.84

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .065 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.41 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR NITROGEN

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF REYNOLDS, ET AL (REF 55)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.1000	769.6	774.81 .677	
.1500	692.2	693.26 .153	
.2000	610.4	606.52 -.636	
.2500	537.4	534.63 -.515	
.3000	481.6	478.65 -.613	
.3500	435.6	436.92 .303	
.4000	401.6	401.55 -.012	
.4500	370.6	370.91 .084	
.5000	347.8	344.76 -.874	340.04 -2.23
.5500	327.2	323.68 -1.08	
.6000	310.0	307.28 -.877	303.44 -2.12

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.308 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .626 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR NEON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF REYNOLDS, ET AL (REF 56)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.1000	435.7	435.87 .039	
.1500	435.7	438.74 .698	
.2000	420.8	417.72 -.732	
.2500	393.9	393.99 .023	
.3000	368.2	365.68 -.684	
.3500	343.2	341.18 -.589	
.4000	320.8	319.66 -.355	
.4500	302.9	300.71 -.723	
.5000	285.9	284.03 -.654	285.92 .007
.5500	271.3	269.32 -.730	
.6000	258.1	256.16 -.752	258.96 .333

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.405 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .604 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR ARGON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF REYNOLDS, ET AL (REF 56)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF
.1000	491.6	487.80 -.773	
.1500	425.2	427.01 .426	
.2000	369.4	373.13 1.01	
.2500	325.7	328.22 .774	
.3000	290.4	294.13 1.28	
.3500	269.9	269.35 -.204	
.4000	250.3	250.37 .028	
.4500	234.5	234.16 -.145	
.5000	221.7	219.80 -.857	214.41 -3.29
.5500	209.6	208.20 -.668	
.6000	200.5	199.94 -.278	192.41 -4.03

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .054 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .699 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR KRYPTON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF REYNOLDS, ET AL (REF 56)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF
.1000	289.6	284.78 -1.66	
.1500	254.7	247.87 -2.68	
.2000	223.3	220.01 -1.47	
.2500	199.4	198.68 -.361	
.3000	182.6	182.07 -.290	
.3500	169.5	168.96 -.319	
.4000	160.0	158.48 -.950	
.4500	152.0	150.00 -1.32	
.5000	144.8	143.02 -1.23	140.32 -3.09
.5500	138.9	137.14 -1.27	
.6000	133.8	131.99 -1.35	130.96 -2.12

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -1.17 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.35 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR XENON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF REYNOLDS, ET AL (REF 56)

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.1000	232.6	229.89 -1.17	
.1500	207.8	207.56 -.115	
.2000	192.2	190.99 -.630	
.2500	177.4	176.50 -.507	
.3000	164.6	163.39 -.735	
.3500	153.5	151.92 -1.03	
.4000	144.4	142.31 -1.45	
.4500	136.9	134.29 -1.91	
.5000	131.5	127.31 -3.19	117.89 -10.3
.5500	125.9	120.88 -3.99	
.6000	121.4	114.89 -5.36	106.66 -12.1

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -1.82 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.42 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 4.0 PERCENT

## THIS COMPARISON IS FOR LITHIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*	*WILLIAMSON*
		PRCT DIFF	PRCT DIFF	PRCT DIFF
.1000	754.9	751.84 -.405		
.1500	669.9	675.80 .881		
.2000	598.7	606.44 1.29		
.2500	546.7	546.29 -.075		
.3000	498.9	495.71 -.639		
.3500	458.2	453.72 -.978		
.4000	423.5	418.70 -1.13		
.4500	390.5	389.01 -.382		
.5000	360.1	363.27 .880	366.58 1.80	341.79 -5.08
.5500	338.4	340.59 .647		
.6000	316.7	320.54 1.21	327.09 3.28	302.20 -4.58
.7000	285.5	288.06 .897	296.13 3.72	272.43 -4.58
.8000	262.9	261.99 -.346	271.05 3.10	249.00 -5.29
.9000	242.1	253.44 4.68	250.18 3.34	229.94 -5.02
1.000	227.3	244.87 7.73	232.11 2.12	214.05 -5.83
1.200	208.2	214.46 3.01		188.85 -9.29
1.400	195.2	191.27 -2.01		169.62 -13.1

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .898 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.47 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

THIS COMPARISON IS FOR BERYLLIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*		BARKAS, ET AL		**BICHSEL**		HILL, ET AL*		*WILLIAMSON*	
		PRCT	DIFF	PRCT	DIFF	PRCT	DIFF	PRCT	DIFF	PRCT	DIFF
.1000	698.3	699.89	.228							348.00	5.01
.1500	654.8	630.27	-3.75							305.81	-3.65
.2000	583.3	565.05	-3.13							273.83	-5.35
.2500	516.5	508.27	-1.59							248.78	-6.93
.3000	469.7	461.13	-1.82							226.58	-7.53
.3500	430.3	422.99	-1.70							211.92	-7.54
.4000	399.6	392.19	-1.85							185.93	-7.86
.4500	372.8	366.75	-1.62							166.43	-7.74
.5000	350.8	325.09	-7.33					342.59	3.38	151.16	-8.05
.5500	331.4	344.82	4.05					305.80	-3.65	138.80	-8.50
.6000	317.4	306.87	-3.32							128.55	-7.45
.7000	289.3	275.56	-4.75							116.04	-9.56
.8000	267.3	255.05	-4.58							105.99	-14.2
.9000	247.2	237.68	-3.85								
1.000	229.2	220.28	-3.89								
1.200	201.8	194.53	-3.60								
1.400	180.4	174.56	-3.24								
1.600	164.4	158.60	-3.53								
1.800	151.7	145.54	-4.06								
2.000	138.9	134.63	-3.07								
2.300	128.3	121.26	-5.49								
2.600	123.6	110.50	-10.6								
				138.82	-.058	134.00	-3.53	134.22	-3.37		

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -3.30 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 4.25 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT



## THIS COMPARISON IS FOR FLUORINE

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF	*WILLIAMSON*	PRCT DIFF
.3000	386.7	395.92	2.38		
.3500	361.4	363.29	.523		
.4000	339.1	336.41	-.793		
.4500	313.8	314.49	.220		
.5000	294.7	296.75	.696	304.69	3.39
.5500	278.9	282.41	1.23		
.6000	272.6	270.62	-.704	274.72	.778

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .512 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.15 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR ALUMINUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*	*WILLIAMSON*
		PRCT DIFF	PRCT DIFF	PRCT DIFF
.2000	390.6	344.46 -11.8		
.3000	328.1	305.58 -6.86		
.4000	279.0	276.04 -1.06		
.5000	256.7	251.99 -1.83	255.92 -.304	258.87 .845
.6000	241.1	229.99 -4.61	233.22 -3.27	236.89 -1.75

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -5.24 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 6.52 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR CALCIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.2000	389.1	392.01 .748	
.3000	320.0	320.34 .106	
.4000	264.5	265.61 .420	
.5000	229.9	232.60 1.17	229.35 -.239
.6000	214.8	213.40 -.652	206.71 -3.77

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .359 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .714 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR VANADIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.2000	353.4	354.49 .308	
.3000	299.0	298.33 -.224	
.4000	252.9	254.19 .510	
.5000	218.6	220.57 .901	196.57 -10.1
.6000	196.2	195.97 -.117	178.79 -8.87

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .276 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .496 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR CHROMIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF
.2000	338.1	337.99 -.033	
.3000	288.3	287.65 -.225	
.4000	247.8	248.17 .149	
.5000	213.0	218.01 2.35	198.44 -6.84
.6000	198.0	195.63 -1.20	180.87 -8.65

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .209 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.19 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR IRON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF
.2000	295.5	295.35 -.051	
.3000	263.1	263.65 .209	
.4000	227.5	227.15 -.154	
.5000	195.1	197.26 1.11	192.21 -1.48
.6000	181.1	179.80 -.718	176.18 -2.72

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .079 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .602 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR COBALT

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.2000	262.6	264.16 .594	
.3000	231.9	232.36 .198	
.4000	201.3	200.93 -.184	
.5000	175.7	177.74 1.16	185.23 5.42
.6000	170.0	170.09 .053	170.30 .176

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .365 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .596 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR NICKEL

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.2000	249.2	251.26 .827	
.3000	235.9	234.47 -.606	
.4000	205.1	206.16 .517	
.5000	180.5	181.60 .609	189.09 4.76
.6000	171.3	164.93 -3.72	174.37 1.79

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.474 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.76 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR COPPER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*	*WILLIAMSON*
		PRCT DIFF	PRCT DIFF	PRCT DIFF
.1000	227.5	225.66 -.809		
.1500	227.5	227.21 -.127		
.2000	217.0	221.45 2.05		
.2500	205.7	211.34 2.74		
.3000	199.0	200.95 .980		
.3500	191.5	191.12 -.198		
.4000	181.8	182.31 .281		
.4500	178.2	174.49 -2.08		
.5000	171.6	167.45 -2.42	177.41 3.39	139.37 -18.8
.5500	165.0	160.94 -2.93		
.6000	160.1	154.86 -3.27	164.11 2.50	136.17 -14.9

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.526 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.98 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR ZINC

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.2000	223.8	218.84 -2.22	
.3000	211.8	194.08 -8.37	
.4000	187.9	175.37 -6.67	
.5000	171.3	160.34 -6.40	174.03 1.59
.6000	162.1	146.93 -9.36	161.51 -.364

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -6.60 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 7.04 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR GOLD

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	HILL, ET AL*	PRCT DIFF	*WILLIAMSON*	PRCT DIFF
.1000	105.5	104.91	-.559		
.1500	115.8	116.33	.458		
.2000	118.9	118.68	-.185		
.2500	115.8	115.79	-.009		
.3000	110.7	110.35	-.316		
.3500	103.9	104.08	.173		
.4000	97.22	98.012	.815		
.4500	91.71	92.637	1.01		
.5000	86.82	88.077	1.45	38.605	-55.5
.5500	83.42	84.229	.921		
.6000	80.40	80.891	.611	40.461	-49.7

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .397 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .719 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

## THIS COMPARISON IS FOR LEAD

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BADER, ET AL (REF 42)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF	HILL, ET AL*	PRCT DIFF	*WILLIAMSON*	PRCT DIFF
.1000	120.9	121.90	.827				
.1500	127.0	127.51	.402				
.2000	126.7	126.11	-.466				
.2500	121.2	120.48	-.594				
.3000	113.3	113.18	-.106				
.3500	106.1	106.01	-.085				
.4000	99.98	99.802	-.178				
.4500	93.88	94.678	.850				
.5000	88.94	90.308	1.54	86.467	-2.78	36.363	-59.1
.5500	84.86	86.326	1.73				
.6000	81.38	79.850	-1.88	80.110	-1.56	36.157	-55.1

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .185 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.00 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

THIS COMPARISON IS FOR HYDROGEN

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	**BARKAS** PRCT DIFF	*RICH,HADEY* PRCT DIFF	HILL, ET AL* PRCT DIFF	*WILLIAMSON* PRCT DIFF
.1000	3480.	3480.7 .020			1180.1 .008	1156.1 -2.03
.1500	2810.	2807.7 -.082			1027.0 .686	1015.0 -.490
.2000	2330.	2330.8 .034			911.90 .209	906.61 -.373
.2500	1990.	1990.8 .040			821.92 .973	820.64 .616
.3000	1740.	1743.1 .178			749.42 1.82	750.65 1.99
.3500	1560.	1555.7 -.276			689.65 2.02	692.48 2.44
.4000	1410.	1407.2 -.199				643.32 2.44
.4500	1280.	1284.1 .320				601.17 2.76
.5000	1180.	1179.7 -.025				564.61 3.03
.5500	1090.	1091.2 .110				532.56 3.41
.6000	1020.	1017.7 -.225				504.22 1.86
.7000	910.0	910.67 .074				478.98 1.91
.8000	814.0	813.91 -.011				435.88 2.56
.9000	736.0	748.89 1.75		690.76 2.17		400.41 1.89
1.0000	676.0	683.80 1.15				334.02 1.84
1.1000	628.0	634.12 .975				287.64 2.00
1.2000	585.0	591.73 1.15				253.28 2.13
1.5000	548.0	555.10 1.30				226.73 2.13
1.7000	515.0	523.10 1.57				205.55 2.26
1.8000	495.0	494.88 -.024				188.23 2.30
2.0000	470.0	469.79 -.045				173.79 2.23
2.5000	425.0	427.02 .475	385.77 -1.84		394.96 .499	151.56 2.25
3.0000	393.0	392.02 -.249				
3.5000	328.0	326.63 -.418		283.40 .496	283.07 .379	
4.0000	282.0	281.09 -.323				
4.5000	222.0	227.43 .230			222.93 .419	
5.0000	201.0	221.44 .252				
5.5000	184.0	200.74 .129		185.20 .652	185.01 .549	
6.0000	170.0	183.82 .093				
	158.0	169.72 .165	158.37 .234	159.00 .633	158.77 .487	
		157.77 -.146				

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .202 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .620 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS COMPARISON IS FOR HELIUM					
THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICKSELS SUMMARY IN REFERENCE 4					
E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	***BARKAS***	HILL, ET AL*	*WILLIAMSON*
		PRCT DIFF	PRCT DIFF	PRCT DIFF	PRCT DIFF
.1000	1095.	1096.1			
.1500	955.0	954.64			
.2000	832.0	832.61			
.2500	736.0	736.13			
.3000	662.0	661.65			
.3500	602.0	602.87			
.4000	554.0	554.41			
.4500	513.0	513.14			
.5000	478.0	477.81			
.5500	448.0	447.86			
.6000	422.0	422.19			
.7000	375.0	374.95			
.8000	341.0	341.01			
.9000	312.0	313.03			
1.000	290.0	285.03			
1.100	268.0	265.39			
1.200	250.0	248.54			
1.300	235.0	233.89			
1.400	222.0	221.03			
1.500	210.0	209.63			
1.600	200.0	199.47			
1.800	183.0	182.07			
2.000	168.0	167.71			
2.500	140.0	140.70			
3.000	121.0	121.72			
3.500	106.0	107.59			
4.000	95.00	96.617			
4.500	86.00	87.835			
5.000	80.00	80.632			
5.500	74.00	74.668			
6.000	68.00	69.489			
			169.43	167.50	164.85
					139.20
				121.58	120.93
					107.20
			98.358	96.514	96.480
					87.853
				80.550	80.750
			70.137	69.421	74.793
					69.719
					422.44
					378.10
					343.17
					314.77
					291.15
					271.14
					253.95
					239.00
					225.86
					214.21
					203.01
					194.46
					178.32
					164.85
					139.20
					120.93
					107.20
					96.480
					87.853
					80.750
					74.793
					69.719

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .180 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .835 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT



THIS COMPARISON IS FOR LITHIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICKSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF	WILLIAMSON* PRCT DIFF	ARON* PRCT DIFF	ARON, ET AL* PRCT DIFF
.1000	752.0	751.84 -.021				
.1500	675.0	675.80 .119				
.2000	608.0	608.44 -.057				
.2500	545.0	546.29 .237				
.3000	496.0	495.71 -.058				
.3500	454.0	453.72 -.062				
.4000	418.0	418.70 .167				
.4500	390.0	389.01 -.254				
.5000	363.0	363.27 .074	366.58 .986	341.79 -5.84		
.5500	340.0	340.59 .174				
.6000	321.0	320.54 -.143	327.09 1.90	302.20 -5.86		
.7000	288.0	288.06 .021	296.13 2.82	272.43 -5.81		
.8000	262.0	261.99 -.004	271.05 3.45	249.00 -4.96		
.9000	243.0	253.44 4.30	250.18 2.95	229.94 -5.37		
1.000	230.0	244.87 6.47	232.11 .917	214.05 -6.93	258.71 12.5	258.71 12.5
1.100	220.0	228.56 3.89		200.53 -8.85		
1.200	212.0	214.46 1.16		188.1 -10.9		
1.300	204.0	202.14 -.912		178.84 -12.4		
1.400	195.0	191.27 -1.91		169.62 -13.0		
1.500	188.0	181.61 -3.40		161.57 -14.1		
1.600	184.0	172.96 -6.00		154.34 -16.1		
1.800	173.0	158.11 -8.61		141.86 -18.0		
2.000	164.0	145.80 -11.1	140.01 -14.6	131.45 -19.8	151.18 -7.82	151.18 -7.82
2.500	148.0	122.54 -17.2		111.54 -24.6		

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -1.39 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 5.09 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS COMPARISON IS FOR BERYLLIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	BARKAS, ET AL PRCT DIFF	**BICHSEL*** PRCT DIFF	*RICH, MADEY* PRCT DIFF	HILL, ET AL* PRCT DIFF	STERNHEIMER* PRCT DIFF
.1000	760.0	699.89	-.016				
.1500	640.0	630.27	-1.52				
.2000	565.0	565.05	.009				
.2500	505.0	508.27	.640				
.3000	460.0	461.13	.246				
.3500	425.0	422.99	-.473				
.4000	390.0	392.19	.562				
.4500	367.0	366.75	-.068				
.5000	345.0	344.92	-.052				
.5500	327.0	325.09	-.584				
.6000	305.0	306.87	.613				
.7000	276.0	275.56	-.159			342.59	-.699
.8000	255.0	255.05	.020			305.80	.262
.9000	236.0	237.68	.712			277.18	.428
1.000	220.0	220.28	.127			254.46	-.212
1.100	209.0	206.53	-1.18			235.45	-.233
1.200	198.0	194.53	-1.75			219.29	-.323
1.300	187.0	183.95	-1.63		247.00		
1.400	179.0	174.56	-2.48				
1.500	170.0	166.16	-2.26				
1.600	161.0	158.60	-1.49				
1.800	148.0	145.54	-1.66				
2.000	137.0	134.63	-1.73				
2.500	116.0	113.84	-1.86			131.90	-3.72
3.000	101.0	99.024	-1.96			98.909	-2.07
3.500	90.00	87.879	-2.36				
4.000	81.00	79.167	-2.26			79.223	-2.19
4.500	73.00	72.154	-1.16				
5.000	67.00	66.376	-.931			66.462	-.803
5.500	62.00	61.527	-.763				
6.000	58.00	57.394	-1.04			56.690	-2.26

247.00 12.3

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.854 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.31 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS COMPARISON IS FOR BERYLLIUM  
THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E (MEV)	EXPERIMENTAL DATA	WILLIAMSON* PRCT DIFF	ARON*** PRCT DIFF	ARON, ET AL* PRCT DIFF
.1000	700.0			
.1500	640.0			
.2000	565.0			
.2500	505.0			
.3000	460.0			
.3500	425.0			
.4000	390.0			
.4500	367.0			
.5000	345.0	348.00 .875		
.5500	327.0			
.6000	305.0	305.81 .266		
.7000	276.0	273.83 -.786		
.8000	255.0	246.78 -2.44		
.9000	236.0	228.58 -3.14		
1.000	220.0	211.92 -3.67	231.05 5.02	246.97 12.3
1.100	209.0	197.91 -5.31		
1.200	198.0	185.93 -6.10		
1.300	187.0	175.54 -6.13		
1.400	179.0	166.43 -7.02		
1.500	170.0	158.36 -6.85		
1.600	161.0	151.16 -6.11		
1.800	148.0	138.80 -6.22		
2.000	137.0	137.89 .650	145.87 6.47	
2.500	116.0	109.12 -5.93		
3.000	101.0	95.271 -5.67		106.05 5.00
3.500	90.00	84.831 -5.74		
4.000	81.00	76.640 -5.38	80.267 -.905	84.267 4.03
4.500	73.00	70.021 -4.08		
5.000	67.00	64.548 -3.66		70.377 5.04
5.500	62.00	59.539 -3.32		
6.000	58.00	58.011 .019	60.687 4.63	

THIS COMPARISON IS FOR CARBON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	BARKAS, ET AL PRCT DIFF	*RICH, MADEY* PRCT DIFF	HILL, ET AL* PRCT DIFF	*WILLIAMSON* PRCT DIFF	***** PRCT DIFF
.1000	822.92			357.62	379.14	
.1500	720.41			317.99	337.11	
.2000	635.71			287.96	303.90	
.2500	566.14			263.91	276.98	
.3000	509.25			243.93	254.71	
.3500	462.81			227.34	235.98	
.4000	424.85				220.03	
.4500	393.63				206.28	
.5000	367.65				194.31	
.5500	345.65				183.80	
.6000	326.61				174.49	
.7000	294.48				166.18	
.8000	267.87				151.99	
.9000	249.38				140.31	
1.000	230.88		241.80		138.39	236.29
1.100	216.26		5.13		128.02	
1.200	203.65				118.39	
1.300	192.64				109.39	
1.400	182.92				100.10	
1.500	174.26				91.564	
1.600	166.48				83.704	
1.800	153.08				75.482	
2.000	141.89				69.581	
2.500	120.53				64.624	
3.000	105.22				60.395	
3.500	93.658					
4.000	84.577					
4.500	77.109					
5.000	71.081					
5.500	66.001					
6.000	61.656					
		146.06	149.70	140.15	146.94	146.94
		2.14	4.69	-1.99	2.76	2.76
			3.58	-1.79		
		86.414	87.580	83.704	86.209	86.209
		1.66	3.04	-1.52	1.42	1.42
			73.400	70.459		
			3.38	-1.762		
		61.760	63.450	61.110	62.533	62.533
		-.387	2.34	-1.44	-.860	-.860

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.077 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .411 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS COMPARISON IS FOR CARBON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	*ARON, ET AL* PRCT DIFF	STERNHEIMER* PRCT DIFF
.1000	823.0		
.1500	720.0		
.2000	636.0		
.2500	567.0		
.3000	508.0		
.3500	463.0		
.4000	426.0		
.4500	392.0		
.5000	368.0		
.5500	346.0		
.6000	327.0		
.7000	294.0		
.8000	268.0		
.9000	246.0		
1.000	230.0	241.76	5.11
1.100	216.0		
1.200	204.0		
1.300	192.0		
1.400	183.0		
1.500	175.0		
1.600	167.0		
1.800	154.0		
2.000	143.0	149.68	4.67
2.500	121.0	109.76	3.55
3.000	106.0		
3.500	94.00	87.583	3.04
4.000	83.00		
4.500	77.00	73.396	3.37
5.000	71.00		
5.500	66.00	63.452	2.34
6.000	62.00		
			140.60 -1.68
			104.40 -1.51
			83.970 -1.21
			70.740 -.366
			61.290 -1.15

THIS COMPARISON IS FOR NITROGEN

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(NEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF	*WILLIAMSON* PRCT DIFF
.1000	775.0	774.81 -.025		
.1500	692.0	693.26 .182		
.2000	610.0	606.52 -.570		
.2500	530.0	534.63 .674		
.3000	482.0	478.65 -.695		
.3500	438.0	436.92 -.247		
.4000	400.0	401.55 .387		
.4500	371.0	370.91 -.024		
.5000	345.0	344.76 -.070	340.04 -1.44	357.62 3.66
.5500	324.0	323.68 -.099		
.6000	307.0	307.28 .091	303.44 -1.16	319.82 4.18
.7000	278.0	277.95 -.018	275.13 -1.03	289.78 4.24
.8000	254.0	254.00 0.	252.04 -.772	265.27 4.44
.9000	235.0	238.30 1.40	233.13 -.796	244.84 4.19
1.0000	220.0	222.58 1.17	217.50 -1.14	227.53 3.42
1.1000	206.0	208.44 1.18		212.67 3.24
1.2000	194.0	196.24 1.15		199.76 2.97
1.3000	185.0	185.58 .314		188.44 1.86
1.4000	176.0	176.18 .102		178.43 1.38
1.5000	168.0	167.82 -.107		169.53 .911
1.6000	160.0	160.33 .206		161.55 .969
1.8000	146.0	147.44 .378		147.84 -.105
2.0000	137.0	136.71 -.212	134.74 -1.65	136.49 -.372
2.5000	117.0	116.26 -.632		115.11 -1.62
3.0000	102.0	101.62 -.373	100.41 -1.56	100.09 -1.87
3.5000	91.00	90.559 -.485		88.899 -2.31
4.0000	82.00	81.863 -.167	80.970 -1.26	80.206 -2.19
4.5000	75.00	74.828 -.229		73.232 -2.36
5.0000	69.00	69.006 .009	68.309 -1.00	67.498 -2.18
5.5000	64.00	64.101 .158		62.688 -2.05
6.0000	60.00	59.828 -.287	59.329 -1.12	58.588 -2.35

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .085 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .546 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS COMPARISON IS FOR OXYGEN

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E (MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF	*WILLIAMSON* PRCT DIFF
.1000	610.0	610.76	322.73 -3.95	338.62 .782
.1500	600.0	600.68	289.34 -3.87	304.13 1.04
.2000	544.0	543.55	262.94 -3.33	276.56 1.68
.2500	495.0	494.09	241.67 -4.10	253.98 .786
.3000	450.0	450.79	224.64 -3.85	235.10 .901
.3500	413.0	413.32	209.05 -4.54	219.05 .023
.4000	382.0	381.69		205.22 .598
.4500	365.0	355.72		193.16 .604
.5000	336.0	334.64		182.54 .297
.5500	317.0	317.17		173.11 .064
.6000	301.0	301.66		164.68 -.194
.7000	272.0	271.73		157.13 .064
.8000	252.0	252.03		144.01 .007
.9000	233.0	237.50		133.09 -.679
1.000	219.0	222.95		112.38 -1.42
1.100	204.0	208.61		97.724 -2.28
1.200	192.0	196.26		86.777 -2.17
1.300	182.0	185.48		78.266 -2.14
1.400	173.0	175.97		71.441 -2.14
1.500	165.0	167.51		65.832 -3.19
1.600	157.0	159.94		61.132 -2.97
1.800	144.0	146.92		57.129 -3.17
2.000	134.0	136.11	130.06 -2.94	
2.500	114.0	115.61	97.160 -2.84	
3.000	100.0	101.00	78.574 -1.78	
3.500	89.00	89.990	66.408 -2.34	
4.000	80.00	81.350	57.758 -2.11	
4.500	73.00	74.365		
5.000	68.00	68.588		
5.500	63.00	63.721		
6.000	59.00	59.559		

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .847 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.35 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS COMPARISON IS FOR NEON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	BARKAS, ET AL PRCT DIFF	HILL, ET AL* PRCT DIFF	*WILLIAMSON* PRCT DIFF
.1000	435.0	435.83		285.92	303.63
.1500	438.0	.191			
.2000	438.74	.169		258.96	274.79
.2500	417.0	.173		237.48	251.31
.3000	393.0	.252		219.48	231.86
.3500	364.0	.187		204.30	215.48
.4000	341.0	.053		191.45	201.48
.4500	319.0	.207			189.37
.5000	300.0	.237			178.78
.5500	285.0	-.340			169.42
.6000	269.0	.119			161.08
.6500	256.0	.062			153.61
.7000	232.0	-.039			146.85
.7500	214.0	.005			135.13
.8000	202.0	2.36			125.28
.8500	191.0	3.43			106.35
.9000	179.0	3.24			92.736
.9500	164.0	3.38			82.459
1.000	156.0	2.94			74.413
1.200	149.0	2.43			67.934
1.400	144.0	1.08			62.598
1.600	137.0	1.63			58.122
1.800	127.0	1.05			54.308
2.000	119.0	.185	124.28 4.44	121.06 1.73	
2.500	102.0	-.225		90.928 1.03	
3.000	90.00	-.431			
3.500	80.00	.065			
4.000	73.00	-.629	75.063 2.83	73.718 .984	
4.500	67.00	-.803		62.455 .734	
5.000	62.00	-.929			
5.500	59.00	-1.43			
6.000	54.00	-.870	54.041 .076	54.464 .859	

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .572 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.44 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT



THIS COMPARISON IS FOR ALUMINUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICKSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	BARKAS, ET AL PRCT DIFF	**BICKSEL** PRCT DIFF	HILL, ET AL* PRCT DIFF	*WILLIAMSON* PRCT DIFF	STERNWEIMER* PRCT DIFF
.1000	420.0	418.06					
.1500	380.0	371.51					
.2000	343.0	344.46					
.2500	327.0	323.56					
.3000	310.0	305.50					
.3500	293.0	289.78					
.4000	279.0	276.04					
.4500	265.0	263.60					
.5000	252.0	251.99			255.92	250.87	
.5500	241.0	240.68					
.6000	230.0	229.99			233.22	236.89	
.7000	212.0	212.01			214.41	218.40	
.8000	197.0	196.99			198.62	202.74	
.9000	185.0	185.51			185.22	189.34	
1.000	173.0	174.02			173.72	177.76	
1.100	163.0	163.92				167.65	
1.200	155.0	155.65				158.75	
1.300	147.0	147.81				150.84	
1.400	140.0	140.88				143.77	
1.500	134.3	134.63				137.40	
1.600	129.0	128.96				131.64	
1.800	119.0	119.11	112.40	1.54	110.30	121.59	110.80
2.000	110.7	110.82				113.12	.090
2.500	94.70	94.806			83.115	96.732	83.160
3.000	83.20	83.278				84.828	.048
3.500	74.50	74.522			67.550	75.744	
4.000	67.60	67.606	68.576	1.44		68.560	.237
4.500	62.00	61.992				62.724	
5.000	57.30	57.335			57.320	57.883	57.190
5.500	53.40	53.402				53.798	.192
6.000	50.00	50.135	49.597	-.806	50.039	50.303	49.840
				.072	.078	.606	.320

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.117 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .642 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS COMPARISON IS FOR ALUMINUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF RICHSELS SUMMARY IN REFERENCE 4

E(KEV)	EXPERIMENTAL DATA	*RICH,HADEY* PRCT DIFF	****ARON**** PRCT DIFF
1000	420.0		
1500	380.0		
2000	343.0		
2500	327.0		
3000	310.0		
3500	293.0		
4000	279.0		
4500	265.0		
5000	252.0		
5500	241.0		
6000	230.0		
7000	212.0		
8000	197.0		
9000	185.0		
10000	173.0		
11000	163.0		
12000	155.0		
13000	147.0		
14000	140.0		
15000	134.3		
16000	129.0		
18000	119.0		
20000	110.7	115.00 3.88	115.00 3.88
25000	94.70	98.500 4.01	
30000	83.20	86.200 3.61	
35000	74.50		
40000	67.60	69.600 2.96	69.600 2.96
45000	62.00		
50000	57.30	58.800 2.62	
55000	53.40		
60000	50.00	51.200 2.40	51.200 2.40

THIS COMPARISON IS FOR ARGON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	BARKAS, ET AL PRCT DIFF	HILL, ET AL* PRCT DIFF
.1000	484.0	487.80 .785		
.1500	427.0	427.01 .002		
.2000	377.0	373.13 -1.03		
.2500	328.0	328.22 .067		
.3000	295.0	294.13 -.295		
.3500	269.0	269.35 .130		
.4000	251.0	250.37 -.251		
.4500	234.0	234.16 .068		
.5000	220.0	219.80 -.091		
.5500	208.0	208.20 .096		
.6000	200.0	199.94 -.030		
.7000	184.0	184.01 .005		
.8000	171.0	170.99 -.006		
.9000	160.0	158.87 -.706		
1.0000	150.0	146.74 -2.17		
1.1000	142.0	138.58 -2.41		
1.2000	134.0	131.45 -1.90		
1.3000	127.0	125.16 -1.45		
1.4000	121.0	119.53 -1.21		
1.5000	116.0	114.47 -1.32		
1.6000	112.0	109.87 -1.90		
1.8000	103.0	101.84 -1.13		
2.0000	95.00	93.035 -11.8	96.061 13.0	94.035 10.6
2.5000	82.00	81.796 -.249		
3.0000	72.00	72.167 .232		
3.5000	65.00	64.756 -.375		
4.0000	59.00	58.991 -.015		
4.5000	54.00	54.242 .448	59.363 .615	58.609 -.663
5.0000	50.00	50.278 .556		
5.5000	47.00	45.918 -.174		
6.0000	44.00	44.026 .059	43.210 -1.80	43.694 -.695

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.079 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.32 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

THIS COMPARISON IS FOR NICKEL

E(NEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF	WILLIAMSON* PRCT DIFF
.2000	247.0	251.26 1.72	189.09 3.90	150.51 -17.3
.2500	247.0	245.30 -.688		146.37 -11.3
.3000	235.0	234.47 -.226	174.37 5.68	140.63 -6.87
.3500	220.0	220.65 .295	161.74 7.11	134.56 -4.57
.4000	206.0	206.16 .078	150.89 7.01	128.64 -3.28
.4500	193.0	192.85 -.078	141.53 6.41	123.05 -3.87
.5000	182.0	181.60 -.220	133.38 4.20	117.84 -3.41
.5500	173.0	172.49 -.295		113.03 -2.56
.6000	165.0	164.93 -.042		108.59 -1.28
.7000	151.0	151.54 .358		104.49 -1.42
.8000	141.0	141.13 .092		100.71 -.287
.9000	133.0	134.97 1.48		97.207 .213
1.0000	128.0	128.79 .617		90.938 -.068
1.100	122.0	121.86 -.115		85.497 .585
1.200	116.0	115.71 -.250		74.593 .808
1.300	110.0	110.22 .264		66.399 .605
1.400	106.0	105.45 -.519		59.992 -.013
1.500	101.0	101.22 .218		54.833 1.54
1.600	97.00	97.375 .387		50.582 1.16
1.800	91.00	90.648 -.387		47.011 .023
2.000	85.00	84.935 -.076	86.471 1.73	43.964 -.082
2.500	74.00	73.893 -.145		41.331 .807
3.000	66.00	65.764 -.358	66.464 .703	
3.500	60.00	59.475 -.875		
4.000	54.00	54.427 .791	54.990 2.83	
4.500	50.00	50.264 .528		
5.000	47.00	46.761 -.509	47.274 .583	
5.500	44.00	43.765 -.534		
6.000	41.00	41.181 .441	41.642 1.57	

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .068 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .580 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICKSELS SUMMARY IN REFERENCE 4

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .312 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .648 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS COMPARISON IS FOR COPPER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	*RICH,MADEY* PRCT DIFF	*ARON* PRCT DIFF	*ARON,ET AL* PRCT DIFF
.1000	228.0			
.1500	228.0			
.2000	221.0			
.2500	211.0			
.3000	201.0			
.3500	192.0			
.4000	183.0			
.4500	175.0			
.5000	168.0			
.5500	161.0			
.6000	155.0			
.7000	144.0			
.8000	135.0			
.9000	128.0			
1.000	121.0			
1.100	114.0			
1.200	109.0			
1.300	104.0			
1.400	99.00			
1.500	95.00			
1.600	92.00			
1.800	85.00			
2.000	80.00			
2.500	70.00			
3.000	62.00			
3.500	56.00			
4.000	51.00			
4.500	47.00			
5.000	44.00	46.080 4.73	47.050 6.93	46.080 4.73
5.500	41.00	40.460 3.74	41.270 5.82	40.460 3.74
6.000	39.00			

THIS COMPARISON IS FOR KRYPTON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	BARKAS ET AL PRCT DIFF	HILL, ET AL* PRCT DIFF
.1000	285.0	284.78 -.077		
.1500	252.0	247.87 -1.64		
.2000	221.0	220.01 -.448		
.2500	198.0	198.68 .343		
.3000	182.0	182.07 .038		
.3500	169.0	168.96 -.024		
.4000	159.0	158.48 -.327		
.4500	150.0	150.00 0.		140.32 -1.87
.5000	143.0	143.02 .014		
.5500	137.0	137.14 .102		
.6000	132.0	131.99 -.008		130.96 -.788
.7000	123.0	122.95 -.041		123.24 .195
.8000	116.0	116.01 .009		116.50 .431
.9000	109.0	110.00 .917		110.55 1.42
1.000	104.0	103.99 -.010		105.23 1.18
1.100	99.00	98.856 -.145		
1.200	94.00	94.346 .368		
1.300	90.00	90.328 .364		
1.400	87.00	86.696 -.349		
1.500	84.00	83.375 -.744		
1.600	81.00	80.356 -.795		
1.800	76.00	75.102 -1.18		
2.000	72.00	70.699 -1.81	72.252 .350	71.563 -.607
2.500	63.00	61.886 -1.77		
3.000	56.00	55.283 -1.28		55.379 -1.11
3.500	50.00	50.126 .252		
4.000	46.00	45.586 -.030	46.234 .509	45.807 -.420
4.500	43.00	42.578 -.981		
5.000	40.00	39.728 -.680		39.529 -1.13
5.500	37.00	37.282 .762		
6.000	35.00	35.169 .483	34.330 -1.91	34.960 -.214

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.280 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .747 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF RICHSELS SUMMARY IN REFERENCE 4

[illegible]

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.565 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.01 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT



THIS COMPARISON IS FOR SILVER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	HILL, ET AL*	PRCT DIFF
.4000	151.0		
.4500	142.0		
.5000	134.0	128.05	-4.44
.5500	128.0		
.6000	122.0	115.92	-4.98
.7000	113.0	106.53	-5.73
.8000	105.0	99.929	-4.83
.9000	99.00	94.536	-4.51
1.000	94.00	89.902	-4.36
1.100	89.00		
1.200	85.00		
1.300	82.00		
1.400	79.00		
1.500	75.00		
1.600	72.00		
1.800	68.00		
2.000	64.00	63.746	-.397
2.500	56.00		
3.000	51.00	50.484	-1.01
3.500	46.00		
4.000	42.00	42.302	.719
4.500	39.00		
5.000	37.00	36.639	-.976
5.500	34.00		
6.000	32.00	32.467	1.46

THIS COMPARISON IS FOR TIN

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF
.4000	142.0	145.09 2.18	
.4500	134.0	135.61 1.20	
.5000	127.0	127.69 .543	129.40 1.89
.5500	121.0	121.10 .083	
.6000	115.0	115.61 .530	116.33 1.16
.7000	107.0	106.97 -.028	106.28 -.673
.8000	100.0	99.919 -.081	98.263 -1.74
.9000	94.00	94.257 .273	92.129 -1.99
1.000	89.00	88.591 -.460	87.392 -1.81
1.100	85.00	84.296 -.828	
1.200	81.00	80.465 -.660	
1.300	78.00	77.018 -1.26	
1.400	75.00	73.924 -1.43	
1.500	71.00	71.123 .173	
1.600	68.00	68.640 .941	
1.800	65.00	64.259 -1.14	
2.000	61.00	60.510 -.803	60.808 -.315
2.500	53.00	53.156 .294	
3.000	48.00	47.710 -.604	48.131 .273
3.500	44.00	43.457 -1.23	
4.000	40.00	40.016 .040	40.236 .590
4.500	37.00	37.160 .432	
5.000	35.00	34.740 -.743	34.845 -.443
5.500	33.00	32.739 -.791	
6.000	31.00	30.926 -.239	30.903 -.313

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.145 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .850 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS COMPARISON IS FOR XENON

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E (MEV)	EXPERIMENTAL DATA	THIS REPORT- PRCT DIFF	BARKAS, ET AL PRCT DIFF	HILL, ET AL PRCT DIFF
.1000	230.0	229.89 -.048		
.1500	207.0	207.56 .271		
.2000	192.0	190.99 -.526		
.2500	176.0	176.50 .284		
.3000	163.0	163.39 .239		
.3500	152.0	151.92 -.053		
.4000	143.0	142.31 -.483		
.4500	134.0	134.29 .216		
.5000	127.0	127.31 .244		117.89 -7.17
.5500	121.0	120.88 -.099		
.6000	115.0	114.89 -.096		106.66 -7.25
.7000	106.0	106.04 .038		97.862 -7.68
.8000	98.00	97.994 -.006		91.148 -6.99
.9000	92.00	89.374 -2.85		85.457 -7.11
1.000	87.00	80.751 -7.18		80.688 -7.26
1.100	82.00	77.261 -5.78		
1.200	78.00	74.067 -5.04		
1.300	75.00	71.144 -5.14		
1.400	72.00	68.466 -4.91		
1.500	69.00	66.009 -4.33		
1.600	66.00	63.750 -3.41		
1.800	62.00	59.746 -3.64	584.79 891.	56.300 -4.58
2.000	59.00	56.301 -4.57		45.109 -4.02
2.500	52.00	49.483 -4.84		
3.000	47.00	44.485 -5.35	383.95 824.	37.931 -2.74
3.500	43.00	40.565 -5.66		
4.000	39.00	37.421 -4.05		33.936 -.188
4.500	36.00	34.809 -3.31		
5.000	34.00	32.594 -4.14		
5.500	32.00	30.687 -4.10	289.73 866.	29.250 -2.50
6.000	30.00	29.024 -3.25		

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -2.63 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 3.55 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS COMPARISON IS FOR GOLD					
THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4					
E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	BARKAS, ET AL PRCT DIFF	HILL, ET AL* PRCT DIFF	WILLIAMSON* PRCT DIFF
.1000	105.0	104.91			
.1500	116.0	116.33			
.2000	119.0	118.68			
.2500	116.0	115.79			
.3000	110.0	110.35			
.3500	104.0	104.06			
.4000	99.00	98.012			
.4500	93.00	92.637			
.5000	88.00	88.077		90.926	38.605
.5500	84.00	84.229			
.6000	81.00	80.891		85.129	40.461
.7000	75.00	74.994		79.976	41.883
.8000	70.00	70.003		75.985	42.971
.9000	66.00	66.803		71.871	43.777
1.000	63.00	63.601		68.348	44.350
1.100	59.60	61.270			44.724
1.200	57.00	59.084		85.129	44.925
1.300	54.30	57.073		79.976	44.975
1.400	52.50	55.155		75.985	44.829
1.500	50.50	53.544		71.871	44.505
1.600	49.00	52.023		68.348	44.062
1.800	46.80	49.237			42.961
2.000	44.00	46.761	47.870	47.648	41.723
2.500	39.60	41.651	8.80	8.29	38.566
3.000	36.40	37.679		38.125	35.677
3.500	33.90	34.495			33.152
4.000	31.60	31.882	32.311	32.319	30.961
4.500	29.60	29.707	2.25	2.28	29.056
5.000	27.70	27.849		28.279	27.390
5.500	26.20	26.234		2.09	25.922
6.000	24.80	24.862	24.831	2.02	24.619

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.76 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.87 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

WILLIAMSON'S LARGE ERROR IS BECAUSE HE USED ONLY A K-SHELL CORRECTION

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

[illegible]

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.095 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.57 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

THIS COMPARISON IS FOR LEAD

E(MEV)	EXPERIMENTAL DATA	WILLIAMSON* PRCT DIFF	*****ARON***** PRCT DIFF	ARON,ET AL* PRCT DIFF
.1000	122.0			
.1500	127.0			
.2000	127.0			
.2500	120.0			
.3000	113.0			
.3500	106.0			
.4000	100.0			
.4500	95.00			
.5000	90.00			
.5500	86.00	36.363 -59.6		
.6000	83.00	38.157 -54.0		
.7000	77.00	39.549 -48.6		
.8000	71.00	40.622 -42.8		
.9000	67.00	41.436 -38.2		
1.000	63.00	42.031 -33.3		
1.100	60.00	42.441 -29.3	71.435 13.4	61.810 -1.89
1.200	57.50	42.269 -26.5		
1.300	55.00	42.797 -22.2		
1.400	53.00	42.760 -19.3		
1.500	51.50	42.542 -17.4		
1.600	50.00	42.192 -15.6		
1.800	47.00	41.253 -12.2		
2.000	44.50	40.147 -9.78	51.304 15.3	46.985 5.58
2.500	40.00	37.242 -6.90		
3.000	36.50	34.531 -5.39	41.418 13.5	38.534 5.57
3.500	33.80	32.137 -4.92		
4.000	31.80	30.049 -5.51	34.923 9.82	32.756 3.01
5.000	27.90	28.226 -5.28		
5.500	26.50	26.628 -4.56		
6.000	25.00	25.216 -4.85	26.940 7.76	25.491 1.96
		23.961 -4.16		

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	THIS REPORT		BARKAS, ET AL		**BICHSEL**		HILL, ET AL		STERNHEIMER		*RICH, MADEY*	
			PRCT DIFF		PRCT DIFF		PRCT DIFF		PRCT DIFF		PRCT DIFF		PRCT DIFF
1.000	728.0	729.86	.255										
1.150	650.0	665.21	2.34										
1.200	584.0	586.10	.360										
1.250	520.0	523.0	-.566										
1.300	478.0	467.53	-2.19										
1.350	433.0	427.21	-1.34										
1.400	408.0	393.12	-3.65										
1.450	375.0	363.92	-2.95										
1.500	354.0	339.23	-4.17										
1.550	333.0	319.22	-4.14										
1.600	312.0	303.23	-2.81										
1.700	284.0	274.11	-3.48										
1.800	242.0	251.42	3.67										
1.900	242.0	236.08	-2.45										
1.000	223.0	220.72	-1.02										
1.100	210.0	206.69	-1.58										
1.200	198.0	194.58	-1.73										
1.300	186.0	184.00	-1.08										
1.400	177.0	174.68	-1.31										
1.500	168.0	166.38	-.964										
1.600	160.0	158.95	-.656										
1.800	147.0	146.15	-.578										
2.000	136.0	135.50	-.368	141.70	4.19	136.40	.294	133.38	-1.93	134.00	-1.47		
2.500	116.0	115.22	-.672			115.90	-.086					102.00	.990
3.000	101.0	100.72	-.277			101.20	.198	99.463	-1.52	99.860	-1.13		
3.500	90.00	89.766	-.260			90.110	.122					81.730	.901
4.000	81.00	81.158	.195	84.161	3.90	81.420	.519	80.260	-.914	80.530	-.580		
4.500	74.00	74.193	.261			74.400	.541					68.680	-.464
5.000	69.00	68.429	-.828			68.590	-.594	67.740	-1.83	68.000	-1.45		
5.500	64.00	63.572	-.669			63.690	-.484					59.380	.644
6.000	59.00	59.361	.612	60.216	2.06	59.490	.831	58.854	-2.27	85.990	45.7		

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -127 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.98 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10, PERCENT

THIS COMPARISON IS FOR WATER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SUMMARY IN REFERENCE 4

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	**BICHSEL** PRCT DIFF	HILL, ET AL* PRCT DIFF	*RICH,MADEY* PRCT DIFF	BARKAS,ET AL PRCT DIFF
.1000	912.0	931.91				
.1500	826.0	847.65				
.2000	735.0	743.55				
.2500	662.0	661.57				
.3000	600.0	595.40				
.3500	543.0	541.15				
.4000	500.0	496.45				
.4500	460.0	459.61		401.53		
.5000	430.0	429.20				
.5500	400.0	403.78				
.6000	376.0	381.79				
.7000	341.0	343.23		357.60		
.8000	310.0	314.91		323.32		
.9000	286.0	291.44		295.88		
1.000	264.0	267.95		273.31		
1.100	259.0	250.25		254.25	279.40	5.83
1.200	233.0	235.04				
1.300	220.0	221.78				
1.400	208.0	210.12				
1.500	197.0	199.76				
1.600	178.0	190.50				
1.800	172.0	174.62				
2.000	159.0	161.46	159.80	155.41	167.60	170.11
2.500	135.0	136.58	134.60			
3.000	117.0	118.96	117.20	115.10	122.76	
3.500	104.0	105.72	104.20			
4.000	94.00	95.376	93.950	92.574	97.930	100.03
4.500	86.00	87.038	85.730			
5.000	79.00	80.160	78.960	77.954	82.000	
5.500	73.00	74.379	73.270			
6.000	68.00	69.446	68.410	67.621	70.900	71.390

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .959 PERCENT  
THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.50 PERCENT  
THE EXPERIMENTAL ERROR IS APPROXIMATELY 1.0 TO 10. PERCENT

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF NIELSEN (REFERENCES 130, 131)

[illegible]

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .512 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .634 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT



THIS COMPARISON IS FOR ALUMINUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF NIELSEN (Ref. 130)

E(MEV)	EXPERIMENTAL DATA	STERNWEIMER*	PRCT DIFF
1.000	172.4		
1.500	133.3		
2.000	109.9	110.80	.819
2.500	94.20		
3.000	82.80	83.160	.435
3.500	74.20		
4.000	67.40	67.440	.059
4.500	62.00		
5.000	57.40	57.190	-.366

THIS COMPARISON IS FOR NICKEL

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF NIELSEN (Ref. 130)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	HILL, ET AL*	*WILLIAMSON*
		PRCT DIFF	PRCT DIFF	PRCT DIFF
1.000	126.8	128.79 1.57	133.38 5.19	123.05 -2.96
1.500	100.8	101.22 .417		100.71 -.089
2.000	84.60	84.973 .441	86.471 2.27	85.497 1.06
2.500	73.50	73.893 .535		74.598 1.49
3.000	65.40	65.764 .557	66.464 1.63	66.399 1.53
3.500	59.30	59.475 .295		59.992 1.17
4.000	54.40	54.427 .050	54.990 1.08	54.833 .796
4.500	50.50	50.264 -.467		50.582 .162
5.000	47.40	46.761 -1.35	47.274 -.266	47.011 -.821

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .228 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .785 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

# THIS COMPARISON IS FOR SILVER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF NIELSEN (Ref. 130)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF	BARKAS, ET AL* PRCT DIFF	**BICHSEL*** PRCT DIFF	*WILLIAMSON* PRCT DIFF	*ARON, ET AL* PRCT DIFF
1.000	93.7	92.620 -1.15	89.902 -4.05			79.759 -14.9	
1.500	74.80	74.628 -.230				70.212 -6.13	
2.000	64.00	63.693 -.480	63.746 -.397	65.775 2.77	63.940 -.094	61.746 -3.52	
2.500	56.40	55.971 -.761			56.300 -.177	55.049 -2.40	
3.000	50.70	50.214 -.959	63.746 25.7		50.550 -.296	49.732 -1.91	
3.500	46.40	45.699 -1.51			46.010 -.841	45.431 -2.09	
4.000	42.90	42.055 -1.97	42.302 -1.39	42.787 -.263	42.260 -1.45	41.883 -2.37	44.229 3.10
4.500	40.00	39.038 -2.40			39.200 -2.00	38.905 -2.74	
5.000	37.50	36.488 -2.70	36.639 -2.30		36.610 -2.37	36.367 -3.02	

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -1.35 PERCENT  
THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.58 PERCENT  
THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

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# THIS COMPARISON IS FOR COPPER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF NIELSEN (Ref. 130)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	BARKAS, ET AL* PRCT DIFF	**BICHSEL** PRCT DIFF	HILL, ET AL* PRCT DIFF	*WILLIAMSON* PRCT DIFF	STERNHEIMER* PRCT DIFF
1.500	95.00	95.778 .819				94.800 -.213	
2.000	80.00	80.408 .510				80.632 .790	
2.500	69.50	69.921 .606	83.224 4.03	81.080 1.35	70.791 -11.5	70.437 1.35	78.930 -1.34
3.000	62.20	62.325 .201		70.390 1.28	64.235 -7.58	62.748 .681	61.830 -.595
3.500	56.50	56.384 -.205		62.550 .563	58.729 -5.58	56.728 .404	
4.000	51.70	51.618 -.159	52.615 1.77	56.510 .018	54.143 -4.17	51.875 .338	51.270 -.832
4.500	47.50	47.688 .396		51.700 0.	50.278 -2.75	47.872 .783	
				47.740 .505	47.000 -1.05		

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .310 PERCENT  
THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .472 PERCENT  
THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

THIS COMPARISON IS FOR GOLD

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF NIELSEN (Ref. 130)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	BARAKAS, ET AL PRCT DIFF	HILL, ET AL* PRCT DIFF	WILLIAMSON* PRCT DIFF
1.500	50.70	53.544	5.61		44.505
2.000	44.00	46.761	6.27		-12.2
2.500	40.00	41.651	4.13	47.648	5.18
3.000	36.50	37.679	3.23		38.566
3.500	34.00	34.495	1.46	38.125	-3.58
4.000	32.00	31.882	-1.369	4.45	-2.25
4.500	29.50	29.707	.702	32.319	-2.49
				.997	30.961
					-3.25
					29.056
					-1.51

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 3.00 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 3.80 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 PERCENT

THIS COMPARISON IS FOR SILVER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF NIELSEN (Ref. 130)

E(MEV)	EXPERIMENTAL DATA	*****ARON**** PRCT DIFF
1.000	93.70	
1.500	74.80	
2.000	64.00	
2.500	56.40	
3.000	50.70	
3.500	46.40	
4.000	42.90	
4.500	40.00	
5.000	37.50	
		46.436
		8.24

THIS COMPARISON IS FOR BERYLLIUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF KAHN AND WARSHAW (REFS 20,54)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	PRCT DIFF	*WILLIAMSON*	PRCT DIFF	HILL, ET AL*	PRCT DIFF
.1000	615.0	699.89	13.8				
.1500	521.0	630.27	21.0				
.2000	467.5	535.35	20.9				
.2500	433.0	508.27	17.4				
.3000	405.0	461.13	13.9				
.3500	380.8	422.99	11.1				
.4000	360.0	392.19	8.94				
.4500	342.0	366.75	7.24				
.5000	325.0	344.82	6.10				
.5500	310.8	325.09	4.60				
.6000	297.5	306.87	3.15				
.6500	284.2	291.21	2.47				
.7000	272.5	275.56	1.12				
.7500	266.3	265.30	.376				
.8000	250.9	255.05	1.65				
.8500	241.0	246.36	2.22				
.9000	231.7	237.68	2.58				
.9500	223.0	228.99	2.69				
1.000	215.0	220.28	2.46				
1.050	206.3	213.17	3.33				
1.100	198.0	206.53	4.31				
1.150	190.8	200.34	5.00				
1.200	184.5	194.53	5.44				
1.250	178.8	189.08	5.75				
1.300	173.3	183.95	6.15				
1.350	168.5	179.12	6.30				
				348.00	7.08	342.59	5.41
				305.81	2.79	305.80	2.79
				273.83	.488	277.18	1.72
				248.78	-.845	254.46	1.42
				228.58	-1.35	235.45	1.62
				211.92	-1.43	219.29	2.00
				197.91	-.045		
				185.93	.775		
				175.54	1.29		

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 6.89 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 9.02 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 15. PERCENT

THIS COMPARISON IS FOR ALUMINUM

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF KAHN AND WARSHAW (REFS 20,54)

E(HEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	*WILLIAMSON* PRCT DIFF	HILL, ET AL* PRCT DIFF
.1000	416.0	418.06		
.1500	366.0	371.51		
.2000	333.5	344.46		
.2500	314.5	323.66		
.3000	297.0	305.58		
.3500	283.0	289.78		
.4000	271.0	276.04		
.4500	260.0	263.68		
.5000	250.0	251.99	258.87	255.92
.5500	241.0	240.68	3.55	2.37
.6000	233.0	229.99	1.67	233.22
.6500	223.5	220.98		.094
.7000	217.0	212.01	218.40	214.41
.7500	210.0	204.50	.645	-1.19
.8000	202.5	196.99		198.62
.8500	196.0	191.25	.119	-1.92
.9000	189.5	185.51		185.22
.9500	183.0	179.77	-0.084	-2.26
1.000	177.0	174.02		173.72
1.050	171.0	168.77	.429	-1.85
1.100	166.5	163.93		
1.150	162.0	159.51	167.65	.691
1.200	157.5	155.48		
1.250	154.0	151.68	158.75	.794
1.300	150.5	147.81		
1.350	146.5	143.31	150.84	.226

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.452 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.95 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 TO 4.5 PERCENT

THIS COMPARISON IS FOR COPPER				
THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF KAHN AND WARSHAW (REFS 20,54)				
E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	WILLIAMSON* PRCT DIFF	HILL, ET AL* PRCT DIFF
.1000	223.5	225.64 .966		
.1500	228.0	227.21 -.346		
.2000	222.0	221.45 -.248		
.2500	212.0	211.34 -.311		
.3000	200.0	200.95 .475		
.3500	189.5	191.92 1.28		
.4000	180.5	182.31 1.00		
.4500	172.5	174.49 1.15		
.5000	166.0	167.45 .873	139.37 -16.0	177.41 6.87
.5500	160.0	160.94 .587		
.6000	154.0	154.86 .558	136.17 -11.6	167.11 6.56
.6500	143.5	149.45 .640		
.7000	144.0	144.04 .028	131.24 -8.86	152.51 5.91
.7500	140.0	139.65 -.250		
.8000	136.0	135.27 -.537	125.84 -7.47	142.46 4.75
.8500	132.0	131.85 -.114		
.9000	129.7	128.44 -.202	120.49 -6.38	133.77 3.94
.9500	126.0	125.02 -.778		
1.000	122.0	121.60 -.328	115.40 -5.41	126.16 3.41
1.050	119.5	118.26 -1.04		
1.100	117.0	115.15 -2.58	110.63 -5.44	
1.150	114.7	112.22 -2.16		
1.200	112.5	109.47 -2.69	106.20 -5.60	
1.250	110.0	106.87 -2.85		
1.300	109.0	104.46 -4.17	102.10 -6.33	
1.350	107.0	102.06 -4.62		

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.564 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.65 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 TO 4.5 PERCENT

THIS COMPARISON IS FOR GOLD

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF KAHN AND WARSHAW (REFS 20,54)

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	*WILLIAMSON*	HILL, ET AL*
		PRCT DIFF	PRCT DIFF	PRCT DIFF
.1000	87.00	104.91 20.6		
.1500	90.00	116.33 29.3		
.2000	88.50	118.62 34.1		
.2500	84.50	115.79 37.0		
.3000	80.50	110.35 37.1		
.3500	77.20	104.08 34.8		
.4000	74.50	98.012 31.6		
.4500	72.00	92.637 28.7		
.5000	69.50	88.077 26.7	39.605 -44.5	90.926 30.8
.5500	67.50	84.229 24.8	40.461 -38.7	85.129 29.0
.6000	66.00	80.891 22.6		
.6500	64.50	77.942 20.8	41.886 -34.0	79.976 25.9
.7000	63.50	74.994 18.1		
.7500	62.00	72.498 16.9	42.971 -28.6	75.985 26.2
.8000	60.20	70.003 16.3		
.8500	59.00	68.403 15.9	43.777 -25.2	71.871 22.9
.9000	58.50	66.803 14.2		
.9500	58.00	65.202 12.4	44.350 -22.2	68.343 19.9
1.000	57.00	63.601 11.6		
1.050	56.50	62.415 10.5		
1.100	55.20	61.270 11.0	44.724 -19.0	
1.150	54.70	60.160 9.98		
1.200	54.00	59.084 9.41	44.925 -16.8	
1.250	53.50	58.047 8.50		

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 21.0 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 22.9 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY 3.0 TO 4.5 PERCENT  
THIS EXPERIMENTAL DATA STRONGLY DISAGREES WITH THAT OF REFS 4,41, AND 42

THIS COMPARISON IS FOR NICKEL

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SELECTION IN REF. 21

E(MEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	HILL, ET AL* PRCT DIFF	*WILLIAMSON* PRCT DIFF
.5000	180.0	181.60	189.09	150.51
.6000	166.0	164.93	174.37	146.37
.8000	141.0	141.13	150.89	134.56
1.000	124.0	126.79	133.38	123.05
1.200	113.0	115.71		113.03
1.400	103.0	105.45		104.49
1.600	96.50	97.375		97.207
1.800	90.00	90.648	86.471	90.938
2.000	87.00	84.935		85.497
2.500	78.00	73.893		74.598
12.00	25.23	24.979	25.190	24.854
20.00	17.05	17.066	17.154	16.847
29.00	12.84	12.883		12.649

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS .184 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.21 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY .20 TO 3.0 PERCENT



THIS COMPARISON IS FOR COPPER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF SIXSELS SELECTION IN REF. 21

E(MEV)	EXPERIMENTAL DATA	THIS REPORT PRCT DIFF	BARKAS, ET AL PRCT DIFF	**SICHSEL** PRCT DIFF	HILL, ET AL PRCT DIFF	WILLIAMSON PRCT DIFF	STERNWEIMER PRCT DIFF
.5000	166.0	167.45			177.41	139.37	
.6000	157.0	154.86			164.11	136.17	
.8000	135.0	135.27			142.46	125.84	
1.000	121.0	121.60			126.16	115.40	
1.200	111.0	109.47				106.20	
1.400	104.0	99.834				98.311	
1.600	94.50	92.062				91.546	
1.800	88.50	85.765				85.710	
2.000	83.50	80.408	83.224	81.080	82.165	80.032	78.930
2.500	74.00	69.921		70.390		70.437	
12.00	23.87	23.738		23.756	23.928	23.582	23.380
20.00	16.22	16.236		16.235	16.306	16.004	15.910
29.00	12.15	12.263		12.251		12.023	
267.0	2.610	2.5731					
300.0	2.422	2.4138	2.4216	2.4130	2.4184		2.3660
615.0	1.772	1.7616					
651.0	1.740	1.7292					

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -1.33 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.24 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY .50 TO 5.0 PERCENT

THIS COMPARISON IS FOR COPPER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SELECTION IN REF. 21

E(MEV)	EXPERIMENTAL DATA	*RICH,MADEY* PRCT DIFF	***ARON*** PRCT DIFF	*ARON,ET AL* PRCT DIFF
.5000	166.0			
.6000	157.0			
.8000	235.0			
1.000	121.0			
1.200	111.0			
1.400	104.0			
1.600	94.50			
1.800	88.50			
2.000	83.50			
2.500	74.00			
12.00	23.87	24.240 1.55	24.650 3.27	24.240 1.55
20.00	16.22	16.420 1.23	16.670 2.77	16.420 1.23
29.00	12.15			
267.0	2.610			
300.0	2.422	2.4020 -.826	2.4260 .165	2.4020 -.826
615.0	1.772			
651.0	1.740			

THIS COMPARISON IS FOR SILVER

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SELECTION IN REF. 21

E (MEV)	EXPERIMENTAL DATA	THIS REPORT*	BARKAS, ET AL PRCT DIFF	**BICHSEL** PRCT DIFF	*WILLIAMSON* PRCT DIFF	****ARON**** PRCT DIFF	*ARON, ET AL* PRCT DIFF
.5000	135.0	134.57			79.200		
.6000	121.0	121.63			81.141		
.8000	104.0	103.26			82.138		
1.0000	93.00	92.620			79.759		
1.2000	84.50	84.231			76.039		
1.4000	80.00	77.506			72.118		
1.6000	72.50	72.232			68.370		
1.8000	68.00	67.619			64.906		
2.0000	64.30	63.693	65.775	2.29	61.740		
2.5000	58.50	55.971		2.940 - .560	55.849		
3.0000	52.00	50.214		56.300 - 3.76	49.732		
3.5000	48.00	45.699		50.550 - 2.79	45.431		
4.0000	40.48	40.278		46.010 - 4.15	45.937		
4.5000	34.13	34.095		20.268 - 1.04	19.937		
5.0000	28.57	28.221		14.039 - .644	13.731		
5.5000	24.198	23.820		10.877 1.01	10.415		
				2.1722 - 1.17			
						21.320	20.575
						14.569	14.116
						2.1864	2.1424
							-2.53

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -1.50 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 2.21 PERCENT

THE EXPERIMENTAL ERROR IS APPROXIMATELY .30 TO 4.0 PERCENT

THIS COMPARISON IS FOR SILVER  
THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SELECTION IN REF. 21

E(MEV)	EXPERIMENTAL DATA	HILL, ET AL*	PRCT DIFF
.5000	135.0	128.05	-5.15
.6000	121.0	115.92	-4.20
.8000	104.0	99.929	-3.91
1.000	93.00	89.902	-3.33
1.200	84.50		
1.400	80.00		
1.600	72.50		
1.800	68.00		
2.000	64.30	63.746	-.862
2.500	58.50		
3.000	52.00	50.484	-2.92
3.500	48.00		
12.00	20.48	20.253	-1.11
20.00	14.13	14.032	-.694
29.00	10.57		
300.0	2.198	2.1698	-1.28

THIS COMPARISON IS FOR GOLD  
THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SELECTION IN REF. 21

E(KEV)	EXPERIMENTAL DATA	THIS REPORT* PRCT DIFF	BARKAS, ET AL PRCT DIFF	HILL, ET AL* PRCT DIFF	*WILLIAMSON* PRCT DIFF
.5000	88.00	68.977 .028		90.926 3.32	38.605 -56.1
.6000	81.00	60.891 -.135		85.129 5.10	40.461 -50.0
.7000	75.00	74.994 -.008		79.976 6.63	41.886 -44.2
.8000	71.00	70.003 -1.40		75.985 7.02	42.971 -39.5
1.000	65.00	63.601 -2.15		68.348 5.15	44.350 -31.8
1.200	60.00	59.084 -1.53			44.925 -25.1
1.400	56.00	55.155 -1.51			44.829 -19.9
1.600	52.00	52.023 .044			44.062 -15.3
1.800	49.00	49.237 .484			42.961 -12.3
2.000	46.80	46.761 -.083	47.870 2.29	47.648 1.81	41.723 -10.8
2.500	41.50	41.651 .364			38.966 -7.07
3.000	38.00	37.679 -.845		38.125 .329	35.677 -6.11
3.500	34.00	34.495 1.46			33.152 -2.49
4.000	31.40	31.882 1.54	32.311 2.90	32.319 2.93	30.961 -1.40
4.500	29.40	29.707 1.04			29.056 -1.17
5.000	27.60	27.849 .176		28.279 1.72	27.390 -1.47
12.00	16.23	15.922 -1.90		16.090 -.863	15.784 -2.75
20.00	11.38	11.240 -1.23		11.328 -.457	11.677 -2.66
29.00	8.610	8.6618 .602			

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.263 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.11 PERCENT

WILLIAMSON'S LARGE ERROR IS BECAUSE HE USED ONLY A K-SHELL CORRECTION

THIS COMPARISON IS FOR LEAD

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SELECTION IN REF. 21

E(MEV)	EXPERIMENTAL DATA	THIS REPORT*	BARKAS, ET AL PRCT DIFF	**BICHSEL** PRCT DIFF	HILL, ET AL* PRCT DIFF	STERNHEIMER* PRCT DIFF	*RICH, MADEY* PRCT DIFF
.5000	90.00	90.308					
.6000	83.00	82.632			86.467		
.7000	75.00	77.074			80.110		
.8000	70.00	70.991			75.076		
1.0000	64.00	63.087			71.496		
1.2000	59.00	58.205					61.810
1.4000	54.60	54.151					-3.42
1.6000	51.00	50.732					
1.8000	48.50	47.812					
2.0000	46.50	45.273	46.397	45.140	45.903	41.140	46.930
2.5000	41.60	40.311		40.140			1.05
3.0000	36.90	35.971		10.960	11.074	10.730	11.210
3.5000	32.40	31.453					2.00
4.0000	28.00	27.530	2.3417	2.3591			
4.5000	24.00	23.530					
5.0000	20.00	19.461		1.8253	1.8167	1.7470	1.76
5.5000	16.00	15.223	1.8146				
6.0000	12.00	11.3474		1.3277			
6.5000	8.00	7.3246					

THE MEAN PERCENTAGE DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS -.292 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE TABULATED DATA  
OF THIS REPORT FROM THE ABOVE EXPERIMENTAL DATA IS 1.48 PERCENT

THE EXPERIMENTAL POINTS AT 175 AND 190 MEV ARE SCALED ALPHA AND DEUTERON DATA

THIS COMPARISON IS FOR LEAD

THIS IS THE EXPERIMENTAL ENERGY LOSS DATA OF BICHSELS SELECTION IN REF. 21

E(MEV)	EXPERIMENTAL DATA	WILLIAMSON* PRCT DIFF	ARON*** PRCT DIFF	ARON,ET AL* PRCT DIFF
.5000	90.00	36.363 -59.6		
.6000	83.00	38.157 -54.9		
.7000	75.00	39.549 -47.3		
.8000	70.00	40.622 -42.0		
1.000	64.00	42.031 -34.3		
1.200	59.00	42.269 -28.4		
1.400	54.60	42.760 -21.7		
1.600	51.00	42.192 -17.3		
1.800	48.50	41.253 -14.9		
2.000	46.50	40.147 -13.7		
2.500	41.60	37.242 -10.5		
20.00	10.99	10.833 -1.43		
175.0	2.486			
190.0	2.356			
265.0	1.900			
300.0	1.819			
615.0	1.343			
650.0	1.328			
			71.435 11.6	61.810 -3.42
			51.304 10.3	46.985 1.04
			11.659 6.09	11.215 2.05
			2.3729 .717	2.3134 -1.81
			1.8304 .627	1.7872 -1.75
			1.3274 -.045	1.2993 -2.16

## THIS ENERGY LOSS COMPARISON IS FOR ILFORD EMULSION (G-5)

PHOTON ENERGY (MEV)	EXPERIMENTAL ENERGY LOSS MEV/CM	THIS REPORT** MEV/CM	PRCT DIFF
.1000	1500.0 (REF. 133)	1460.8	-2.61
.2000	1130.0 (REF. 133)	1154.5	2.17
.3000	950.00 (REF. 133)	948.84	-.122
.4000	820.00 (REF. 133)	813.40	-.805
.6000	650.00 (REF. 133)	650.55	.085
1.000	490.00 (REF. 133)	483.65	-1.30
1.500	380.00 (REF. 133)	379.38	-.163
2.000	316.00 (REF. 133)	317.72	.544
3.000	244.00 (REF. 133)	244.46	.189
4.000	201.00 (REF. 133)	201.54	.269
5.000	172.00 (REF. 133)	172.94	.547
6.000	151.00 (REF. 133)	152.25	.828
7.000	136.00 (REF. 133)	136.54	.397
8.000	123.00 (REF. 133)	124.12	.911
9.000	113.00 (REF. 133)	114.00	.885
10.00	104.00 (REF. 133)	105.58	1.52
11.00	97.100 (REF. 133)	98.431	1.42
13.00	90.900 (REF. 133)	92.375	1.62
13.00	85.500 (REF. 133)	87.071	1.84
14.00	80.700 (REF. 133)	82.406	2.11

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL ENERGY LOSS DATA IS .517 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL ENERGY LOSS DATA IS 1.26 PERCENT

Most common nuclear emulsions have atomic compositions which are similar. As a result, the various emulsions differ only slightly in their pathlength and stopping power characteristics. Experimental measurements have shown that the stopping power of Ilford E1 emulsion is only 0.3 percent lower than that of Ilford C-2. The stopping power of Ilford G-5 is 1.0 percent greater than the C-2 emulsion, and Kodak NTA has a stopping power 1.8 percent greater than that of the C-2 emulsion (Ref. 135).



THIS PATH LENGTH COMPARISON IS FOR ILFORD EMULSION (G-5)

PROTON ENERGY (MEV)	EXPERIMENTAL PATH LENGTH MICRONS	THIS REPORT** MICRONS	PRCT DIFF
.1000	.92000 (REF. 133)	1.0200	3.03
.2000	1.7800 (REF. 133)	1.7900	.562
.3000	2.7600 (REF. 133)	2.7500	-.362
.4000	3.9100 (REF. 133)	3.8900	-.512
.6000	6.6900 (REF. 133)	6.6600	-.448
1.000	13.920 (REF. 133)	13.890	-.216
1.200	19.300 (REF. 134)	18.260	-5.34
1.295	20.690 (REF. 127)	20.500	-.918
1.500	25.630 (REF. 133)	25.670	.156
2.000	40.010 (REF. 133)	40.140	.325
2.421	53.890 (REF. 127)	54.260	.687
2.450	55.670 (REF. 127)	55.300	-.665
2.590	59.600 (REF. 134)	60.400	1.34
3.000	76.430 (REF. 133)	76.410	-.026
3.200	82.700 (REF. 134)	84.770	2.50
3.250	83.900 (REF. 134)	86.920	3.60
4.000	121.00 (REF. 133)	121.72	.595
4.510	147.00 (REF. 134)	148.12	.762
4.750	159.50 (REF. 134)	161.28	1.12
4.960	170.00 (REF. 134)	173.16	1.87
4.990	171.00 (REF. 134)	174.90	2.28
5.000	175.90 (REF. 133)	175.48	-.239
5.000	175.10 (REF. 127)	175.48	.217
5.477	204.60 (REF. 127)	203.97	-.308
6.000	237.90 (REF. 133)	237.26	-.269
6.240	256.00 (REF. 134)	253.25	-1.07
7.000	307.00 (REF. 127)	306.75	-.341
7.000	321.00 (REF. 134)	313.38	-2.37
8.000	385.30 (REF. 133)	383.67	-.423
9.000	470.30 (REF. 133)	467.83	-.525
9.050	474.00 (REF. 134)	472.22	-.376
9.090	482.00 (REF. 134)	475.75	-1.30
10.00	562.50 (REF. 133)	559.06	-.612
10.00	562.70 (REF. 127)	559.06	-.647
11.00	662.00 (REF. 133)	657.19	-.727
12.00	768.50 (REF. 133)	762.10	-.833
13.00	882.00 (REF. 133)	873.65	-.947
13.06	896.10 (REF. 134)	880.55	-1.74
13.96	988.20 (REF. 127)	986.91	-.131
14.00	1002.4 (REF. 133)	991.76	-1.06
21.21	2056.0 (REF. 127)	2029.0	-1.31
33.64	4580.0 (REF. 80 )	4530.8	-1.07
36.55	5345.0 (REF. 127)	5238.6	-1.99
200.0	10309. (REF. 127)	10036.	-2.65
340.0	24739. (REF. 127)	24120.	-2.50
540.0	51402. (REF. 127)	49833.	-3.05
700.0	74967. (REF. 127)	73388.	-2.11

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL PATH LENGTH DATA IS -.385 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL PATH LENGTH DATA IS 1.62 PERCENT

THE UNITS OF REFERENCE 127 HAVE BEEN CHANGED TO MICRONS FOR PRESENTATION HERE

THIS RANGE COMPARISON IS FOR HYDROGEN

PROTON ENERGY (MEV)	EXPERIMENTAL RANGE GM/CM2	*THIS REPORT** MG/CM2 PRCT DIFF	*WILLIAMSON** MG/CM2 PRCT DIFF
1.000	.83700 (REF. 129)	.83832 .158	
2.000	2.8630 (REF. 129)	2.8524 -.370	
3.000	5.9470 (REF. 129)	5.9087 -.644	
4.000	10.010 (REF. 129)	9.9450 -.649	
5.000	15.020 (REF. 129)	14.920 -.666	9.7834 -2.26
6.000	20.940 (REF. 129)	20.810 -.621	14.660 -2.40
7.000	27.750 (REF. 129)	27.580 -.613	20.425 -2.46
8.000	35.440 (REF. 129)	35.220 -.621	27.056 -2.50
			34.536 -2.55

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL

THE ABOVE EXPERIMENTAL RANGE DATA IS -.503 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL

THE ABOVE EXPERIMENTAL RANGE DATA IS .569 PERCENT

THIS RANGE COMPARISON IS FOR BERYLLIUM

PROTON ENERGY (MEV)	EXPERIMENTAL RANGE GM/CM2	*THIS REPORT** MG/CM2 PRCT DIFF	*WILLIAMSON** MG/CM2 PRCT DIFF
1.000	.00291 (REF. 129)	.00289 -.687	
2.000	.00893 (REF. 129)	.00889 -.680	
3.000	.01753 (REF. 129)	.01755 .685	
4.000	.02882 (REF. 129)	.02902 .694	
5.000	.04259 (REF. 129)	.04285 .610	.03001 4.13
6.000	.05791 (REF. 129)	.05909 2.04	.04432 4.07
7.000	.07614 (REF. 129)	.07764 1.97	.06104 5.40
8.000	.09642 (REF. 129)	.09846 1.90	.08008 3.17
9.578	.13774 (REF. 36)	.13582 -1.39	.10140 4.93
17.34	.39959 (REF. 36)	.39539 -1.05	
339.7	76.680 (REF. 36)	76.980 .391	

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL

THE ABOVE EXPERIMENTAL RANGE DATA IS .531 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL

THE ABOVE EXPERIMENTAL RANGE DATA IS 1.23 PERCENT

PROTON ENERGY (MEV)	THIS RANGE COMPARISON IS FOR IRON				**WILLIAMS**		
	EXPERIMENTAL RANGE MG/CH2	*THIS REPORT*		MG/CH2	PCT DIFF	MG/CH2	PCT DIFF
		MG/CH2	PCT DIFF				
1.000	5.7100 (REF. 129)	5.1592	-9.65				
2.000	14.510 (REF. 129)	14.0615	-3.02				
3.000	28.190 (REF. 129)	27.703	-1.73				
4.000	44.540 (REF. 129)	44.050	-1.10				
5.000	63.390 (REF. 129)	63.470	.126			47.613	5.90
6.000	86.230 (REF. 129)	85.830	-.434			67.431	3.37
7.000	111.00 (REF. 129)	111.02	.018			90.209	4.67
8.000	140.00 (REF. 129)	136.96	-1.31			116.00	4.50
						144.57	2.53

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS -1.67 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS 3.53 PERCENT

THIS RANGE COMPARISON IS FOR COPPER

PROTON ENERGY (MEV)	EXPERIMENTAL RANGE GM/CM2	THIS REPORT**		WILLIAMS**	
		GM/CM2	PCT DIFF	GM/CM2	PCT DIFF
1.000	.00601 (REF. 129)	.00603	.333		
2.000	.01346 (REF. 129)	.01632	5.57		
3.000	.02990 (REF. 129)	.03047	1.91		
4.000	.04743 (REF. 129)	.04804	1.29	.05116	7.86
5.000	.06923 (REF. 129)	.06884	-.563	.07205	4.07
6.000	.09402 (REF. 129)	.09271	-1.39	.09607	2.18
7.000	.12080 (REF. 129)	.11955	-1.03	.12312	1.92
8.000	.15066 (REF. 129)	.14927	-.883	.15311	1.67
9.938	.21580 (REF. 36)	.21477	-.477		
17.89	.58867 (REF. 36)	.58514	-.600		
44.00	2.8200 (REF. 37)	2.7973	-.805	2.8663	1.54
55.70	4.2500 (REF. 37)	4.2278	-.522		
65.20	5.6700 (REF. 37)	5.5705	-1.75		
73.00	6.9300 (REF. 37)	6.9884	.843	6.9816	.745
76.10	7.5100 (REF. 37)	7.3004	-2.79		
79.10	7.9700 (REF. 37)	7.8107	-2.00		
84.00	8.8400 (REF. 37)	8.6750	-1.87	8.9285	1.00
86.90	9.3800 (REF. 37)	9.2044	-1.87		
89.80	9.9500 (REF. 37)	9.7466	-2.04		
96.20	11.210 (REF. 37)	10.988	-1.98		
99.80	11.960 (REF. 37)	11.714	-1.23		
102.1	12.400 (REF. 37)	12.187	-2.35		
109.3	13.680 (REF. 37)	13.501	-1.31		
111.3	14.860 (REF. 37)	14.156	-4.74		
113.7	14.860 (REF. 37)	14.689	-1.15		
337.9	91.430 (REF. 35)	91.859	.469		
338.5	91.360 (REF. 35)	92.122	.834		
339.7	92.270 (REF. 35)	92.649	.411		
658.0	256.40 (REF. 24)	257.55	.449		
752.2	314.90 (REF. 27)	313.04	-.591		

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL

THE ABOVE EXPERIMENTAL RANGE DATA IS -.662 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL

THE ABOVE EXPERIMENTAL RANGE DATA IS 1.89 PERCENT

THIS RANGE COMPARISON IS FOR SILVER

PROTON ENERGY (MEV)	EXPERIMENTAL RANGE GH/CM2	THIS REPORT** PRCT DIFF
10.02	.26166 (REF. 36 )	.26220 .206
17.92	.69198 (REF. 36 )	.68996 -.292

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS -.043 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS .253 PERCENT

THIS RANGE COMPARISON IS FOR TIN

PROTON ENERGY (MEV)	EXPERIMENTAL RANGE MG/CM2	THIS REPORT** MG/CM2 PRCT DIFF
1.000	8.6980 (REF. 129)	7.8687 -9.53
2.000	20.420 (REF. 129)	21.621 5.88
3.000	38.050 (REF. 129)	40.107 5.41
4.000	60.630 (REF. 129)	62.757 3.51
5.000	87.190 (REF. 129)	89.270 2.39
6.000	117.60 (REF. 129)	119.41 1.54
7.000	152.10 (REF. 129)	153.04 .618
8.000	189.50 (REF. 129)	190.07 .301

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS 1.26 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS 4.68 PERCENT

THIS RANGE COMPARISON IS FOR GOLD

PROTON ENERGY (MEV)	EXPERIMENTAL RANGE		THIS REPORT**	
	GM/CH2		GM/CH2	PRCT DIFF
9.608	.32386 (REF. 36 )		.32302	-.259
17.55	.84959 (REF. 36 )		.84827	-.155

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS -.207 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS .214 PERCENT

THIS GOOD AGREEMENT INDICATES CORRECTNESS OF THE NIGAM OVER MOLIERE THEORY

THIS RANGE COMPARISON IS FOR LEAD

PROTON ENERGY (MEV)	EXPERIMENTAL RANGE		THIS REPORT**		WILLIAMS**	
	GM/CH2		GM/CH2	PRCT DIFF	GM/CH2	PRCT DIFF
1.000	.01128 (REF. 129)		.01132	.355		
2.000	.02948 (REF. 129)		.02978	1.02		
3.000	.05405 (REF. 129)		.05387	-.333		
4.000	.08354 (REF. 129)		.08295	-.706	.11716	40.2
5.000	.11740 (REF. 129)		.11673	-.571	.15260	30.8
6.000	.15430 (REF. 129)		.15498	.441	.19226	24.6
7.000	.19520 (REF. 129)		.19752	1.19	.23606	20.9
8.000	.23999 (REF. 129)		.24410	1.71	.28388	19.3

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS .388 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS .911 PERCENT

THIS GOOD AGREEMENT INDICATES CORRECTNESS OF THE NIGAM OVER MOLIERE THEORY

THIS RANGE COMPARISON IS FOR AIR

PROTON ENERGY (MEV)	EXPERIMENTAL RANGE GM/CM2	THIS REPORT	
		GM/CM2	PRCT DIFF
.2320	.0029 (REF. 123)	.0035	20.7
.3290	.0045 (REF. 123)	.0054	20.0
.5000	.0077 (REF. 123)	.0099	28.6
.6570	.0141 (REF. 123)	.0149	5.67
.7660	.0192 (REF. 123)	.0202	5.21
.9830	.0272 (REF. 123)	.0279	2.57
1.184	.0378 (REF. 123)	.0376	.529
1.339	.0448 (REF. 123)	.0458	2.23
1.514	.0550 (REF. 123)	.0559	1.64
1.739	.0689 (REF. 123)	.0702	1.89
1.950	.0838 (REF. 123)	.0848	1.19

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS 8.10 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS 12.5 PERCENT

THE LOW ENERGY ERROR MAY BE THE RESULT OF THE NORMALIZATION AT .1 MEV

THIS RANGE COMPARISON IS FOR ALUMINUM

PROTON ENERGY (MEV)	EXPERIMENTAL RANGE GM/CM2	*THIS REPORT*		**WILLIAMSON**	
		GM/CM2	PRCT DIFF	GM/CM2	PRCT DIFF
.1170	.00026 (REF, 123)	.00026	0.		
.1660	.00039 (REF, 123)	.00042	7.69		
.2570	.00062 (REF, 123)	.00072	5.88		
.3420	.00093 (REF, 123)	.00096	3.23		
.4330	.00126 (REF, 123)	.00129	2.38		
.4960	.00145 (REF, 123)	.00149	2.76		
.5200	.00160 (REF, 123)	.00163	1.88		
.6300	.00207 (REF, 123)	.00209	.966		
.7450	.00260 (REF, 123)	.00263	1.15		
1.000	.00385 (REF, 129)	.00397	3.12		
1.055	.00420 (REF, 123)	.00429	2.14		
1.130	.00466 (REF, 122)	.00475	1.93		
1.352	.00619 (REF, 122)	.00619	0.		
1.393	.00642 (REF, 123)	.00648	.935		
1.389	.00810 (REF, 122)	.00793	-2.10		
1.623	.00827 (REF, 122)	.00819	-.967		
1.342	.01015 (REF, 123)	.00997	-1.77		
1.311	.01062 (REF, 122)	.01057	-1.03		
2.000	.01114 (REF, 129)	.01136	1.97		
2.114	.01264 (REF, 122)	.01240	-1.90		
2.577	.01331 (REF, 122)	.01814	.928		
3.000	.02171 (REF, 129)	.02185	.645		
5.062	.02285 (REF, 122)	.02260	-1.09		
4.000	.03471 (REF, 129)	.03521	1.44	.03504	.951
4.023	.03574 (REF, 122)	.03555	-.532		
5.000	.05083 (REF, 129)	.05128	.885	.05000	.334
5.038	.05231 (REF, 122)	.05194	-.707		
5.504	.06051 (REF, 122)	.06037	-.231		
6.000	.06971 (REF, 129)	.06993	.316	.06960	-.158
6.150	.07301 (REF, 36 )	.07295	-.082		
7.000	.09114 (REF, 129)	.09105	-.099	.09077	-.406
8.000	.11460 (REF, 129)	.11458	-.017	.11443	-.148
11.82	.22633 (REF, 36 )	.22582	-.225		
14.97	.34263 (REF, 36 )	.34189	-.242		
17.84	.46692 (REF, 36 )	.46534	-.328		
18.00	.44700 (REF, 32 )	.47298	5.81	.47718	6.75
34.96	1.5480 (REF, 37 )	1.5370	-.711		
37.16	1.7630 (REF, 37 )	1.7135	-2.81		
39.66	2.9340 (REF, 37 )	1.9244	-.496		
42.57	2.2070 (REF, 37 )	2.1832	-1.08		
44.86	2.3930 (REF, 37 )	2.3968	.159		
52.08	3.1810 (REF, 37 )	3.1769	-.170		
56.96	3.6940 (REF, 37 )	3.6675	-.717		
62.10	4.2690 (REF, 37 )	4.2769	.185		
66.10	4.7740 (REF, 37 )	4.7789	.101		
73.05	5.6990 (REF, 37 )	5.7072	.144		
75.84	6.0630 (REF, 37 )	6.0538	-.508		
87.40	7.8200 (REF, 141)	7.8410	.269		
117.9	13.230 (REF, 141)	13.279	.370		
145.5	19.310 (REF, 141)	19.389	.409		
338.5	78.470 (REF, 35 )	79.569	1.40		
339.7	79.260 (REF, 35 )	80.028	.969		

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS .575 PERCENT  
THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL RANGE DATA IS 2.34 PERCENT  
THE EXPERIMENTAL DATA POINT AT 18 MEV FROM REFERENCE 32 IS PROBABLY IN ERROR



THIS STRAGGLING COMPARISON IS FOR BERYLLIUM

PROTON ENERGY (MEV)	EXPERIMENTAL STRAGGLING PERCENT	*THIS REPORT*		*STERNWEIMER*	
		PERCENT	PRCT DIFF	PERCENT	PRCT DIFF
10.00	1.7100 (REF. 36 )	1.3540	-20.8	1.3820	-19.2
18.00	1.5500 (REF. 36 )	1.2800	-17.4		
339.7	1.1800 (REF. 35 )	.97790	-17.1		

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL STRAGGLING DATA IS -18.5 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL STRAGGLING DATA IS 18.5 PERCENT

THE STRAGGLING SHOULD ACTUALLY BE CORRECTED FOR MULTIPLE SCATTERING EFFECTS

THIS STRAGGLING COMPARISON IS FOR ALUMINUM

PROTON ENERGY (MEV)	EXPERIMENTAL STRAGGLING PERCENT	*THIS REPORT*		*STERNWEIMER*	
		PERCENT	PRCT DIFF	PERCENT	PRCT DIFF
6.000	1.6300 (REF. 36 )	1.6520	1.35	1.7200	5.52
12.00	1.4900 (REF. 36 )	1.4980	.537	1.5070	1.14
15.00	1.4200 (REF. 36 )	1.4560	2.54		
18.00	1.4200 (REF. 36 )	1.4230	.211		
75.80	1.4400 (REF. 37 )	1.2200	-15.3		
338.5	1.1700 (REF. 35 )	1.0380	-11.3		
339.7	1.3100 (REF. 35 )	1.0380	-20.6		

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL STRAGGLING DATA IS -6.10 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL STRAGGLING DATA IS 10.7 PERCENT

THE STRAGGLING SHOULD ACTUALLY BE CORRECTED FOR MULTIPLE SCATTERING EFFECTS

THIS STRAGGLING COMPARISON IS FOR COPPER

PROTON ENERGY (MEV)	EXPERIMENTAL STRAGGLING PERCENT	*THIS REPORT*		*STERNWEIMER*	
		PERCENT	PRCT DIFF	PERCENT	PRCT DIFF
10.00	1.7100 (REF. 36 )	1.7290	1.11	1.7490	2.28
18.00	1.5500 (REF. 36 )	1.5840	2.19		
72.60	1.9200 (REF. 37 )	1.3180	-31.4		
110.0	1.8100 (REF. 37 )	1.2540	-30.7	1.2850	-29.0
337.9	1.2100 (REF. 35 )	1.0930	-10.3		
338.5	1.3620 (REF. 35 )	1.0920	-19.8		
339.7	1.2430 (REF. 35 )	1.0040	-19.2		

THE MEAN DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL STRAGGLING DATA IS -15.5 PERCENT

THE PERCENT RELATIVE STANDARD DEVIATION OF THE CALCULATIONS OF THIS REPORT FROM ALL  
THE ABOVE EXPERIMENTAL STRAGGLING DATA IS 20.0 PERCENT

THE STERNWEIMER POINT AT 110 MEV WAS OBTAINED BY INTERPOLATION

TABULATIONS (ELEMENTS)

ALPHABETIC LIST OF MATERIALS

ALUMINUM	MOLYBDENUM
ANTIMONY	NEON
ARGON	NICKEL
BERYLLIUM	NITROGEN (DIATOMIC)
BISMUTH	OSMIUM
BORON	OXYGEN (DIATOMIC)
CADMIUM	PLATINUM
CALCIUM	RADIUM
CARBON	SELENIUM
CESIUM	SILICON
CHLORINE	SILVER
CHROMIUM	STRONTIUM
COBALT	TANTALUM
COPPER	THORIUM
FLUORINE	TIN
GERMANIUM	TITANIUM
GOLD	TUNGSTEN
HELIUM	URANIUM
HYDROGEN(DIATOMIC)	VANADIUM
IRON	XENON
KRYPTON	ZINC
LEAD	
LITHIUM	
MAGNESIUM	
MANGANESE	

# ALUMINUM

ELEMENT NUMBER 13  
 ATOMS/ MOLECULE 1  
 ATOMIC WEIGHT 26.981  
 ADJUSTED IONIZATION POTENTIAL 163.0

DENSITY = 2.6990 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH SYRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM2	MEV/CM	MG/CM2	MM	MG/CM2	MM	MG/CM2	MM		
.10	418.06	1128.3	.25660	.00095	.26000	.00096	.00004	3.833	1.310	0.
.15	371.51	1002.7	.38302	.00142	.38680	.00143	.00005	3.651	.9762	0.
.20	344.46	929.70	.52201	.00193	.52655	.00195	.00007	3.436	.8637	0.
.30	305.58	824.76	.82870	.00307	.83521	.00309	.00009	3.053	.7792	0.
.40	276.04	745.65	1.1713	.00434	1.1890	.00437	.00012	2.792	.7359	0.
.50	251.99	680.12	1.5483	.00574	1.5593	.00578	.00015	2.594	.7034	0.
.60	229.99	620.74	1.9614	.00727	1.9748	.00732	.00018	2.448	.6757	0.
.70	212.01	572.21	2.4117	.00894	2.4276	.00899	.00021	2.339	.6517	0.
.80	196.99	531.68	2.8985	.01074	2.9160	.01081	.00024	2.258	.6305	0.
.90	185.51	500.70	3.4186	.01267	3.4396	.01274	.00028	2.199	.6119	0.
1.00	174.02	469.68	3.9725	.01472	3.9963	.01481	.00032	2.153	.5952	0.
1.20	155.48	419.64	5.1858	.01921	5.2153	.01932	.00040	2.088	.5667	0.
1.40	140.88	380.24	6.5327	.02420	6.5684	.02434	.00050	2.040	.5435	0.
1.60	128.96	348.98	8.0116	.02968	8.0537	.02984	.00060	2.001	.5239	0.
1.80	119.11	321.48	9.6231	.03565	9.6721	.03584	.00070	1.967	.5071	.00001
2.00	110.82	299.09	11.355	.04207	11.411	.04228	.00082	1.939	.4930	.00001
2.20	103.74	280.00	13.214	.04896	13.277	.04919	.00094	1.913	.4811	.00001
2.40	97.580	263.37	15.196	.05630	15.267	.05657	.00107	1.889	.4702	.00002
2.60	92.210	248.88	17.298	.06409	17.378	.06439	.00120	1.868	.4605	.00003
2.80	87.483	236.12	19.516	.07231	19.605	.07264	.00134	1.848	.4521	.00004
3.00	83.278	224.77	21.851	.08096	21.948	.08132	.00149	1.830	.4446	.00005
3.20	79.508	214.59	24.300	.09003	24.407	.09043	.00164	1.813	.4377	.00006
3.40	76.104	205.40	26.884	.09953	26.981	.09997	.00180	1.796	.4315	.00007
3.60	73.012	197.06	29.584	.10946	29.688	.10992	.00196	1.781	.4258	.00008
3.80	70.191	189.45	32.322	.11975	32.458	.12026	.00213	1.767	.4207	.00010
4.00	67.606	182.47	35.213	.13047	35.360	.13101	.00230	1.754	.4158	.00012
4.20	65.227	176.05	38.216	.14159	38.374	.14218	.00248	1.741	.4114	.00014
4.40	63.029	170.12	41.325	.15311	41.494	.15374	.00266	1.729	.4072	.00015
4.60	60.993	164.62	44.538	.16502	44.718	.16568	.00285	1.718	.4034	.00018
4.80	59.099	159.51	47.861	.17733	48.053	.17804	.00304	1.707	.3998	.00020

## ALUMINUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING		PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM	PERCENT	PERCENT	
5.00	57.335	154.75	.05128	.01900	.05149	.01908	.00087	.00032	1.697	.3964	.00022
5.50	53.402	144.13	.06029	.02234	.06053	.02243	.00101	.00038	1.673	.3889	.00029
6.00	50.135	135.32	.06993	.02591	.07020	.02601	.00116	.00043	1.652	.3825	.00037
6.50	47.197	127.39	.08019	.02971	.08049	.02982	.00131	.00049	1.632	.3767	.00046
7.00	44.621	120.43	.09105	.03373	.09139	.03386	.00148	.00055	1.614	.3716	.00057
7.50	42.342	114.28	.10251	.03798	.10289	.03812	.00164	.00061	1.598	.3671	.00069
8.00	40.309	108.79	.11456	.04245	.11500	.04261	.00182	.00067	1.583	.3630	.00154
8.50	38.483	103.87	.12725	.04715	.12771	.04732	.00200	.00074	1.570	.3592	.00275
9.00	36.833	99.413	.14049	.05205	.14099	.05224	.00220	.00081	1.557	.3558	.00402
9.50	35.334	95.366	.15430	.05717	.15485	.05737	.00239	.00089	1.546	.3528	.00578
10.00	33.965	91.671	.16868	.06250	.16928	.06272	.00260	.00096	1.535	.3498	.00755
11.00	31.553	85.163	.19916	.07379	.19985	.07405	.00303	.00112	1.515	.3447	.01108
12.00	29.494	79.605	.23186	.08591	.23265	.08620	.00348	.00129	1.498	.3403	.01462
13.00	27.714	74.800	.26675	.09883	.26765	.09917	.00397	.00147	1.482	.3363	.01819
14.00	26.157	70.599	.30379	.11256	.30481	.11293	.00448	.00166	1.468	.3328	.02176
15.00	24.784	66.892	.34297	.12707	.34410	.12749	.00501	.00186	1.456	.3298	.02535
16.00	23.563	63.595	.38425	.14237	.38551	.14283	.00557	.00206	1.444	.3269	.02896
17.00	22.468	60.642	.42759	.15843	.42898	.15893	.00615	.00228	1.433	.3244	.03259
18.00	21.482	57.980	.47298	.17524	.47451	.17581	.00675	.00250	1.423	.3221	.03623
19.00	20.588	55.566	.52040	.19281	.52207	.19343	.00738	.00274	1.414	.3199	.03989
20.00	19.765	53.346	.56984	.21113	.57165	.21180	.00803	.00298	1.406	.3180	.04356
22.00	18.338	49.494	.67467	.24997	.67680	.25076	.00941	.00349	1.390	.3144	.05096
24.00	17.123	46.216	.78727	.29169	.78973	.29260	.01087	.00403	1.376	.3114	.05842
26.00	16.077	43.391	.90754	.33625	.91035	.33729	.01242	.00460	1.364	.3087	.06311
28.00	15.155	40.930	1.0353	.38360	1.0385	.38478	.01405	.00521	1.353	.3063	.06496
30.00	14.363	38.765	1.1705	.43367	1.1741	.43500	.01576	.00584	1.343	.3041	.06688
32.00	13.651	36.844	1.3130	.48646	1.3169	.48794	.01756	.00651	1.333	.3022	.06886
34.00	13.015	35.127	1.4626	.54192	1.4671	.54355	.01943	.00720	1.325	.3005	.07092
36.00	12.443	33.584	1.6194	.60001	1.6243	.60181	.02138	.00792	1.316	.2989	.07303
38.00	11.926	32.188	1.7832	.66067	1.7885	.66264	.02341	.00867	1.309	.2974	.07520
40.00	11.456	30.919	1.9539	.72392	1.9597	.72607	.02551	.00945	1.302	.2960	.07742
45.00	10.448	28.199	2.4102	.89298	2.4173	.89561	.03109	.01152	1.286	.2931	.08318
50.00	9.6250	25.978	2.9079	1.0774	2.9164	1.0805	.03710	.01375	1.272	.2906	.08917
55.00	8.9399	24.129	3.4459	1.2767	3.4558	1.2804	.04354	.01613	1.260	.2884	.09541
60.00	8.3601	22.564	4.0331	1.4906	4.0436	1.4949	.05039	.01867	1.249	.2866	.10194
65.00	7.8627	21.221	4.6385	1.7186	4.6517	1.7235	.05763	.02135	1.239	.2850	.10873
70.00	7.4311	20.057	5.2911	1.9604	5.3062	1.9660	.06525	.02416	1.230	.2835	.11575
75.00	7.0529	19.036	5.9802	2.2157	5.9971	2.2220	.07324	.02713	1.221	.2822	.12296
80.00	6.7186	18.133	6.7049	2.4842	6.7338	2.4912	.08158	.03023	1.213	.2811	.13034
90.00	6.1340	16.610	8.2578	3.0596	8.2809	3.0681	.09929	.03679	1.199	.2791	.14549

# ALUMINUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/CH2	MEV/CM	GH/CH2	CH	GH/CH2	CH	GH/CH2	CM		
100.00	5.6952	15.371	9.9441	3.6044	9.9718	3.6946	.11829	.04383	1.186	.16101
110.00	5.3147	14.344	11.758	4.3566	11.791	4.7786	.13852	.05132	1.175	.17589
120.00	4.9940	13.479	13.696	5.0743	13.733	5.0883	.15991	.05925	1.164	.19316
130.00	4.7198	12.739	15.751	5.8359	15.794	5.8519	.18239	.06758	1.155	.20971
140.00	4.4827	12.099	17.920	6.6396	17.969	6.6578	.20590	.07629	1.146	.22643
150.00	4.2757	11.540	20.199	7.4848	20.254	7.5044	.23041	.08537	1.138	.24322
160.00	4.0932	11.048	22.584	8.3677	22.646	8.3904	.25585	.09477	1.130	.26014
170.00	3.9313	10.611	25.071	9.2891	25.139	9.3143	.28218	.10455	1.122	.27722
180.00	3.7865	10.220	27.657	10.247	27.732	10.275	.30937	.11462	1.116	.29440
190.00	3.6564	9.8687	30.338	11.241	30.420	11.271	.33736	.12499	1.109	.31162
200.00	3.5388	9.5513	33.112	12.268	33.201	12.301	.36613	.13565	1.103	.32824
210.00	3.4321	9.2631	35.974	13.329	36.071	13.364	.39563	.14658	1.097	.34606
220.00	3.3347	9.0003	38.923	14.421	39.027	14.460	.42584	.15778	1.091	.36329
230.00	3.2455	8.7596	41.955	15.543	42.067	15.586	.45672	.16922	1.086	.38051
240.00	3.1636	8.5385	45.068	16.698	45.189	16.743	.48826	.18090	1.080	.39766
250.00	3.0880	8.3346	48.260	17.881	48.389	17.928	.52040	.19281	1.075	.41472
260.00	3.0181	8.1460	51.527	19.091	51.665	19.142	.55314	.20494	1.071	.43165
270.00	2.9533	7.9711	54.868	20.329	55.014	20.383	.58645	.21729	1.066	.44844
280.00	2.8931	7.8084	58.281	21.593	58.436	21.651	.62031	.22983	1.062	.46504
290.00	2.8369	7.6569	61.763	22.884	61.927	22.944	.65469	.24257	1.057	.48145
300.00	2.7845	7.5153	65.312	24.199	65.485	24.263	.68957	.25549	1.053	.49763
310.00	2.7354	7.3827	68.926	25.538	69.109	25.605	.72494	.26860	1.049	.51359
320.00	2.6893	7.2584	72.604	26.900	72.796	26.971	.76077	.28187	1.045	.52933
330.00	2.6460	7.1417	76.343	28.286	76.545	28.361	.79705	.29531	1.041	.54482
340.00	2.6053	7.0317	80.142	29.693	80.354	29.772	.83376	.30891	1.038	.56006
350.00	2.5669	6.9281	84.000	31.122	84.221	31.205	.87088	.32267	1.034	.57504
360.00	2.5307	6.8303	87.913	32.572	88.145	32.658	.90841	.33657	1.031	.58973
370.00	2.4964	6.7378	91.882	34.043	92.123	34.132	.94632	.35062	1.027	.60415
380.00	2.4640	6.6503	95.904	35.533	96.156	35.626	.98460	.36480	1.024	.61827
390.00	2.4332	6.5673	99.977	37.042	100.24	37.140	1.0232	.37914	1.021	.63210
400.00	2.4041	6.4885	104.10	38.570	104.37	38.672	1.0622	.39356	1.018	.64562
410.00	2.3763	6.4137	108.27	40.117	108.56	40.222	1.1015	.40813	1.015	.65881
420.00	2.3500	6.3425	112.50	41.681	112.79	41.790	1.1412	.42282	1.012	.67164
430.00	2.3249	6.2748	116.76	43.262	117.07	43.375	1.1811	.43762	1.009	.68413
440.00	2.3009	6.2102	121.08	44.860	121.39	44.977	1.2214	.45253	1.006	.69627
450.00	2.2781	6.1486	125.43	46.474	125.76	46.595	1.2617	.46755	1.003	.70905
460.00	2.2563	6.0898	129.83	48.104	130.17	48.230	1.3028	.48268	1.001	.71949
470.00	2.2355	6.0335	134.27	49.750	134.62	49.879	1.3439	.49791	.9982	.73058
480.00	2.2156	5.9798	138.76	51.410	139.12	51.544	1.3852	.51323	.9957	.74132
490.00	2.1965	5.9283	143.28	53.086	143.65	53.224	1.4268	.52865	.9933	.75172

# ALUMINUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
500.00	2.1782	147.84	54.775	148.23	54.918	1.4687	.54416	.2594	.76179
510.00	2.1607	152.44	56.479	152.83	56.626	1.5108	.55976	.2592	.77153
520.00	2.1439	157.07	58.196	157.48	58.347	1.5531	.57545	.2590	.78084
530.00	2.1278	161.74	59.927	162.16	60.082	1.5957	.59122	.2588	.79003
540.00	2.1123	166.45	61.670	166.88	61.830	1.6385	.60707	.2585	.79880
550.00	2.0975	171.19	63.426	171.63	63.590	1.6815	.62299	.2583	.80727
560.00	2.0832	175.96	65.194	176.41	65.362	1.7247	.63900	.2581	.81543
570.00	2.0694	180.76	66.974	181.23	67.147	1.7681	.65508	.2579	.82330
580.00	2.0562	185.60	68.766	186.08	68.943	1.8116	.67123	.2577	.83089
590.00	2.0435	190.46	70.569	190.96	70.751	1.8554	.68745	.2574	.83819
600.00	2.0311	195.36	72.383	195.87	72.569	1.8994	.70374	.2572	.84521
620.00	2.0178	205.24	76.043	205.77	76.239	1.9878	.73651	.2568	.85867
640.00	1.9982	215.23	79.745	215.79	79.950	2.0770	.76953	.2564	.87072
660.00	1.9859	225.33	83.486	225.91	83.700	2.1667	.80279	.2559	.88203
680.00	1.9711	235.53	87.264	236.13	87.488	2.2571	.83628	.2555	.89244
700.00	1.9534	245.82	91.078	246.45	91.311	2.3481	.86997	.2551	.90201
720.00	1.9129	256.21	94.926	256.86	95.169	2.4396	.90387	.2545	.91080
740.00	1.8973	266.68	98.807	267.36	99.059	2.5316	.93797	.2542	.91887
760.00	1.8828	277.24	102.72	277.94	102.98	2.6241	.97225	.2538	.92626
780.00	1.8691	287.87	106.66	288.60	106.93	2.7171	1.0067	.2533	.93303
800.00	1.8562	298.59	110.63	299.34	110.91	2.8105	1.0413	.2529	.93921
820.00	1.8440	309.37	114.62	310.15	114.91	2.9044	1.0761	.2525	.94486
840.00	1.8325	320.23	118.65	321.04	118.95	2.9987	1.1111	.2521	.95002
860.00	1.8217	331.15	122.69	331.98	123.00	3.0934	1.1461	.2516	.95471
880.00	1.8115	342.13	126.76	343.00	127.08	3.1885	1.1814	.2512	.95899
900.00	1.8019	353.18	130.86	354.07	131.19	3.2840	1.2167	.2508	.96289
920.00	1.7927	364.29	134.97	365.21	135.31	3.3798	1.2522	.2503	.96643
940.00	1.7841	375.46	139.11	376.40	139.46	3.4759	1.2879	.2498	.96965
960.00	1.7759	386.70	143.27	387.66	143.63	3.5724	1.3236	.2493	.97257
1000.00	1.7607	409.42	151.69	410.44	152.07	3.7663	1.3954	.2479	.97763

THE ELECTRON DENSITY OF ALUMINUM IS 2.903E 23 ELECTRONS PER GRAH

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.182 BEV, AND THE MINIMUM ENERGY LOSS IS 1.6251 MEV/GM/CM2

## ANTIMONY

ATOMIC NUMBER 51  
ELEMENT Sb  
ATOMS/MOLECULE 1  
ADJUSTED IONIZATION POTENTIAL 505.9  
ATOMIC WEIGHT 121.75

DENSITY = 6.6200 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT		PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/CH2	MEV/CM	MG/CH2	MM	MG/CH2	MM	MG/CH2	MM	PERCENT	PERCENT	
.10	238.71	1580.3	.84201	.00127	.87500	.00132	.04191	.00006	4.789	3.771	0.
.15	214.65	1421.0	1.0612	.00160	1.0958	.00166	.04622	.00007	4.218	3.155	0.
.20	195.18	1292.1	1.3018	.00197	1.3400	.00202	.05139	.00008	3.835	2.850	0.
.30	166.43	1101.8	1.8478	.00279	1.8964	.00286	.07396	.00010	3.373	2.562	0.
.40	146.54	970.09	2.4765	.00374	2.5380	.00383	.07960	.00012	3.136	2.426	0.
.50	131.42	870.00	3.1830	.00481	3.2593	.00492	.09911	.00015	3.041	2.341	0.
.60	118.77	786.26	3.9676	.00599	4.0601	.00613	.12155	.00018	2.994	2.278	0.
.70	108.16	716.02	4.8331	.00730	4.9433	.00747	.14662	.00022	2.966	2.229	0.
.80	100.95	668.29	5.7742	.00872	5.9033	.00892	.17357	.00026	2.940	2.188	0.
.90	93.234	617.21	6.7839	.01025	6.9231	.01047	.20195	.00031	2.913	2.152	0.
1.00	85.514	566.11	7.8825	.01191	8.0533	.01217	.23317	.00035	2.895	2.121	0.
1.20	77.918	515.82	10.268	.01554	10.505	.01587	.29949	.00045	2.851	2.070	0.
1.40	71.748	474.97	12.915	.01951	13.183	.01991	.36720	.00055	2.785	2.028	0.
1.60	66.600	440.89	15.759	.02380	16.079	.02429	.43698	.00066	2.718	1.991	0.
1.80	62.408	413.14	18.808	.02841	19.193	.02898	.50895	.00077	2.653	1.958	0.
2.00	58.830	389.46	22.052	.03331	22.486	.03397	.58298	.00088	2.593	1.929	0.
2.20	55.719	368.86	25.486	.03890	25.980	.03924	.65988	.00100	2.540	1.901	0.
2.40	52.990	350.80	29.106	.04397	29.663	.04481	.74064	.00112	2.497	1.875	0.
2.60	50.574	334.80	32.907	.04971	33.528	.05065	.82480	.00125	2.460	1.852	0.
2.80	48.428	320.59	36.882	.05571	37.570	.05675	.91196	.00138	2.427	1.829	0.
3.00	46.494	307.79	41.031	.06198	41.786	.06312	1.0019	.00151	2.398	1.808	0.
3.20	44.740	296.18	45.346	.06850	46.172	.06975	1.0943	.00165	2.370	1.789	0.
3.40	43.140	285.59	49.828	.07527	50.766	.07663	1.1892	.00180	2.344	1.770	0.
3.60	41.672	275.87	54.475	.08229	55.447	.08376	1.2865	.00194	2.320	1.753	0.
3.80	40.320	266.92	59.277	.08954	60.324	.09112	1.3859	.00209	2.297	1.736	0.
4.00	39.068	258.63	64.239	.09704	65.363	.09874	1.4876	.00225	2.276	1.720	0.
4.20	37.905	250.93	69.361	.10478	70.564	.10659	1.5914	.00240	2.255	1.705	0.
4.40	36.821	243.76	74.632	.11274	75.915	.11468	1.6973	.00256	2.236	1.691	0.
4.60	35.808	237.05	80.060	.12094	81.425	.12300	1.8053	.00273	2.217	1.677	0.
4.80	34.859	230.76	85.637	.12936	87.086	.13155	1.9153	.00289	2.199	1.664	0.

ANTIMONY

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
5.00	33.966	224.86	.09137	.01380	.09290	.01403	.00203	.00031	1.651	0.
5.50	31.951	211.52	.10633	.01606	.10808	.01633	.00232	.00035	1.622	0.
6.00	30.202	199.94	.12221	.01846	.12419	.01876	.00262	.00040	1.596	0.
6.50	28.664	189.76	.13897	.02099	.14119	.02133	.00293	.00044	1.572	.00001
7.00	27.355	181.09	.15660	.02366	.15907	.02403	.00325	.00049	1.550	.00001
7.50	26.122	172.93	.17504	.02644	.17776	.02685	.00358	.00054	1.530	.00002
8.00	25.011	165.57	.19438	.02936	.19736	.02981	.00393	.00059	1.512	.00003
8.50	23.994	158.84	.21451	.03240	.21776	.03289	.00428	.00065	1.495	.00004
9.00	23.094	152.89	.23545	.03557	.23899	.03610	.00465	.00070	1.479	.00006
9.50	22.270	147.43	.25721	.03885	.26103	.03943	.00502	.00076	1.464	.00008
10.00	21.510	142.40	.27980	.04227	.28392	.04289	.00541	.00082	1.450	.00010
11.00	20.156	133.43	.32722	.04943	.33195	.05014	.00621	.00094	1.425	.00017
12.00	18.983	125.67	.37722	.05706	.38309	.05784	.00704	.00106	1.403	.00027
13.00	17.955	118.86	.43123	.06514	.43728	.06605	.00792	.00120	1.383	.00039
14.00	17.055	112.91	.48772	.07367	.49446	.07469	.00883	.00133	1.365	.00053
15.00	16.253	107.59	.54709	.08264	.55457	.08377	.00977	.00148	1.348	.00070
16.00	15.531	102.81	.60929	.09204	.61753	.09328	.01076	.00163	1.333	.00089
17.00	14.880	98.505	.67429	.10186	.68331	.10322	.01178	.00178	1.320	.00111
18.00	14.288	94.585	.74209	.11210	.75192	.11358	.01284	.00194	1.307	.00135
19.00	13.747	91.004	.81264	.12276	.82331	.12437	.01394	.00211	1.295	.00161
20.00	13.250	87.718	.88585	.13381	.89737	.13555	.01507	.00228	1.284	.00190
22.00	12.379	81.892	1.0404	.15716	1.0537	.15917	.01743	.00263	1.265	.00505
24.00	11.614	76.883	1.2055	.18210	1.2207	.18440	.00301	.00301	1.247	.00904
26.00	10.956	72.529	1.3609	.20859	1.3981	.21119	.02256	.00341	1.232	.01178
28.00	10.379	68.707	1.5665	.23663	1.5858	.23955	.02531	.00382	1.219	.01321
30.00	9.8667	65.316	1.7620	.26616	1.7835	.26941	.02819	.00426	1.206	.01470
32.00	9.4109	62.300	1.9673	.29718	1.9911	.30077	.03118	.00471	1.195	.01629
34.00	9.0005	59.583	2.1824	.32866	2.2085	.33362	.03429	.00518	1.185	.01785
36.00	8.6296	57.128	2.4073	.36389	2.4356	.36792	.03751	.00567	1.176	.01951
38.00	8.2909	54.886	2.6409	.39893	2.6721	.40364	.04064	.00617	1.168	.02122
40.00	7.9859	52.867	2.8841	.43566	2.9179	.44078	.04428	.00669	1.160	.02297
45.00	7.3270	48.505	3.5316	.53348	3.5725	.53965	.05334	.00806	1.143	.02754
50.00	6.7837	44.908	4.2340	.63958	4.2824	.64688	.06302	.00952	1.128	.03235
55.00	6.3279	41.890	4.9898	.75375	5.0462	.76226	.07329	.01107	1.116	.03740
60.00	5.9394	39.319	5.7975	.87576	5.8624	.88555	.08414	.01271	1.106	.04271
65.00	5.6043	37.100	6.6557	1.0034	6.7295	1.0165	.09534	.01443	1.097	.04825
70.00	5.3120	35.166	7.5631	1.1425	7.6463	1.1550	.10748	.01624	1.089	.05401
75.00	5.0548	33.483	8.5286	1.2888	8.6117	1.3009	.11994	.01812	1.081	.05996
80.00	4.8266	31.952	9.5208	1.4382	9.6243	1.4538	.13289	.02007	1.075	.06608
95.00	4.4392	29.388	11.662	1.7616	11.787	1.7806	.16023	.02420	1.064	.07879



ANTIMONY

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CH2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	4.1227	13.978	14.127	2.1340	.18938	.02861	1.341	.09200
110.00	3.8589	16.462	16.636	2.5130	.22024	.03327	1.324	.10570
120.00	3.6356	19.107	19.308	2.9166	.25270	.03817	1.309	.11992
130.00	3.4441	21.906	22.136	3.3437	.28668	.04330	1.295	.13457
140.00	3.2802	24.853	25.112	3.7933	.32204	.04865	1.282	.14956
150.00	3.1344	27.944	28.234	4.2649	.35875	.05419	1.271	.16484
160.00	3.0056	31.169	31.491	4.7570	.39676	.05993	1.260	.18038
170.00	2.8911	34.531	34.886	5.2698	.43600	.06586	1.250	.19619
180.00	2.7886	38.016	38.406	5.8016	.47640	.07196	1.240	.21222
190.00	2.6963	41.630	42.055	6.3528	.51792	.07824	1.232	.22840
200.00	2.6128	45.362	45.825	6.9222	.56050	.08467	1.223	.24470
210.00	2.5368	49.207	49.709	7.5088	.60408	.09125	1.215	.26104
220.00	2.4675	53.167	53.707	8.1129	.64862	.09798	1.208	.27736
230.00	2.4033	57.234	57.815	8.7333	.69411	.10485	1.201	.29362
240.00	2.3448	61.406	62.028	9.3698	.74047	.11185	1.194	.30978
250.00	2.2909	65.679	66.343	10.022	.78768	.11898	1.187	.32583
260.00	2.2410	70.050	70.757	10.688	.83568	.12624	1.181	.34182
270.00	2.1946	74.516	75.267	11.370	.88445	.13360	1.175	.35782
280.00	2.1515	79.073	79.869	12.065	.93394	.14108	1.169	.37380
290.00	2.1114	83.720	84.561	12.774	.98414	.14866	1.164	.38974
300.00	2.0738	88.452	89.341	13.496	1.0350	.15635	1.158	.40561
310.00	2.0387	93.269	94.204	14.230	1.0865	.16413	1.153	.42136
320.00	2.0057	98.162	99.146	14.977	1.1386	.17200	1.148	.43695
330.00	1.9747	103.14	104.18	15.737	1.1913	.17995	1.144	.45235
340.00	1.9456	108.20	109.28	16.507	1.2446	.18801	1.139	.46755
350.00	1.9181	113.32	114.45	17.289	1.2985	.19614	1.134	.48254
360.00	1.8921	118.52	119.70	18.082	1.3528	.20435	1.130	.49731
370.00	1.8676	123.79	125.02	18.886	1.4076	.21264	1.126	.51188
380.00	1.8443	129.13	130.41	19.700	1.4630	.22099	1.122	.52622
390.00	1.8223	134.53	135.87	20.524	1.5188	.22942	1.118	.54033
400.00	1.8014	139.99	141.39	21.357	1.5750	.23792	1.114	.55420
410.00	1.7816	145.52	146.97	22.201	1.6317	.24648	1.110	.56782
420.00	1.7627	151.11	152.61	23.050	1.6889	.25510	1.107	.58119
430.00	1.7448	156.76	158.31	23.914	1.7462	.26378	1.103	.59431
440.00	1.7276	162.46	164.07	24.785	1.8041	.27252	1.100	.60717
450.00	1.7113	168.22	169.89	25.663	1.8623	.28132	1.096	.61977
460.00	1.6957	174.04	175.76	26.550	1.9209	.29017	1.093	.63209
470.00	1.6809	179.90	181.68	27.445	1.9799	.29907	1.090	.64415
480.00	1.6666	185.82	187.66	28.347	2.0391	.30802	1.087	.65593
490.00	1.6530	191.79	193.68	29.257	2.0987	.31702	1.084	.66744

# ANTIMONY

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM <sup>2</sup>	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH GM/CM <sup>2</sup>	CH	PATH LENGTH STRAGGLING GM/CM <sup>2</sup>	CH	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.6400	197.80	199.76	30.175	2.1586	.32607	1.081	.9785	.67867
510.00	1.6275	203.86	205.88	31.099	2.2188	.33516	1.078	.9779	.68963
520.00	1.6156	209.97	212.04	32.031	2.2793	.34430	1.075	.9773	.70031
530.00	1.6041	216.12	218.26	32.969	2.3400	.35347	1.072	.9767	.71071
540.00	1.5931	222.32	224.51	33.914	2.4010	.36269	1.069	.9762	.72085
550.00	1.5825	228.56	230.81	34.865	2.4623	.37195	1.067	.9756	.73071
560.00	1.5723	234.84	237.15	35.823	2.5238	.38124	1.064	.9750	.74030
570.00	1.5626	241.16	243.53	36.787	2.5856	.39057	1.062	.9745	.74963
580.00	1.5532	247.51	249.95	37.756	2.6476	.39994	1.059	.9739	.75869
590.00	1.5441	253.91	256.40	38.732	2.7098	.40934	1.057	.9734	.76749
600.00	1.5354	260.34	262.90	39.713	2.7723	.41877	1.054	.9728	.77604
620.00	1.5189	273.31	276.00	41.691	2.8978	.43773	1.050	.9717	.79237
640.00	1.5036	286.42	289.23	43.690	3.0241	.45681	1.046	.9707	.80772
660.00	1.4894	299.66	302.59	45.709	3.1512	.47601	1.041	.9696	.82212
680.00	1.4761	313.02	316.08	47.747	3.2789	.49530	1.037	.9685	.83560
700.00	1.4637	326.50	329.69	49.803	3.4073	.51470	1.033	.9674	.84922
720.00	1.4521	340.09	343.41	51.875	3.5364	.53420	1.030	.9663	.86000
740.00	1.4413	353.79	357.24	53.963	3.6660	.55378	1.026	.9653	.87098
760.00	1.4311	367.59	371.17	56.067	3.7962	.57344	1.023	.9643	.88121
780.00	1.4216	381.48	385.19	58.186	3.9269	.59318	1.019	.9632	.89073
800.00	1.4127	395.46	399.30	60.318	4.0581	.61300	1.016	.9621	.89956
820.00	1.4043	409.53	413.50	62.463	4.1897	.63289	1.013	.9610	.90776
840.00	1.3964	423.68	427.79	64.620	4.3218	.65284	1.010	.9599	.91536
860.00	1.3890	437.91	442.15	66.790	4.4544	.67286	1.007	.9588	.92239
880.00	1.3820	452.21	456.59	68.971	4.5873	.69294	1.005	.9578	.92890
900.00	1.3754	466.62	471.13	71.168	4.7206	.71308	1.002	.9568	.93490
920.00	1.3692	481.16	485.80	73.383	4.8542	.73327	.9992	.9551	.94044
940.00	1.3633	495.63	500.46	75.598	4.9882	.75351	.9967	.9538	.94555
960.00	1.3578	510.35	515.26	77.835	5.1226	.77380	.9942	.9537	.95025
1000.00	1.3477	539.93	545.10	82.342	5.3922	.81453	.9892	.9492	.95850

THE ELECTRON DENSITY OF ANTIMONY IS 2.524E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.997 BEV, AND THE MINIMUM ENERGY LOSS IS 1.2722 MEV/GM/CM2

# ARGON

ELEMENT A ATOMIC NUMBER 18 ATOMS/ MOLECULE 1 ADJUSTED IONIZATION POTENTIAL 205.0 ATOMIC WEIGHT 39.948

DENSITY = 1.7836 MG/CM3

PROTON ENERGY MEV	ENERGY LOSS MEV/ GH/CH2	KEV/CM	PROTON RANGE MG/CH2	PROTON PATH LENGTH MG/CH2	PROTON PATH LENGTH METER	MG/CH2	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	487.80	870.04	.20237	.00113	.00115	.00836	.00005	1.685	0.
.15	427.01	761.62	.01154	.00175	.00177	.01100	.00006	1.190	0.
.20	373.13	665.51	.03605	.00244	.00247	.01438	.00008	1.007	0.
.25	294.13	524.61	.07367	.00414	.00417	.02288	.00013	.8605	0.
.30	250.37	446.56	1.1053	.00620	.00625	.03293	.00018	.8034	0.
.40	219.80	392.04	1.5291	.00857	.00864	.04380	.00025	.7725	0.
.50	199.94	356.61	2.0045	.01124	.01132	.05535	.00031	.7514	0.
.60	184.01	328.20	2.5222	.01454	.01425	.06711	.00038	.7351	0.
.70	170.99	304.98	3.0824	.01728	.01741	.07929	.00044	.7209	0.
.80	158.87	283.36	3.6849	.02066	.02081	.09201	.00052	.7082	0.
.90	146.74	261.73	4.3357	.02431	.02448	.10566	.00059	.6966	0.
1.00	131.45	234.46	5.7690	.03234	.03256	.13503	.00076	.6765	0.
1.20	119.53	213.20	7.3572	.04125	.04152	.16613	.00093	.6599	0.
1.40	109.87	195.97	9.0945	.05099	.05132	.19919	.00112	.6454	0.
1.60	101.84	181.64	10.977	.06154	.06193	.23476	.00132	.6326	0.
1.80	95.036	169.51	12.999	.07288	.07334	.27267	.00153	.6212	0.
2.00	89.187	159.07	15.160	.08500	.08552	.31276	.00175	.6109	0.
2.20	84.106	150.00	17.459	.09788	.09848	.35490	.00199	.6013	.00601
2.40	79.633	142.03	19.891	.11152	.11219	.39901	.00224	.5931	.00001
2.60	75.685	134.99	22.455	.12589	.12664	.44500	.00249	.5853	.00001
2.80	72.167	128.72	25.147	.14099	.14181	.49279	.00276	.5761	.00001
3.00	68.976	123.03	27.968	.15681	.15771	.54234	.00304	.5716	.00002
3.20	66.068	117.84	30.917	.17334	.17433	.59373	.00333	.5654	.00002
3.40	63.502	113.26	33.991	.19058	.19165	.64674	.00363	.5598	.00003
3.60	61.148	109.06	37.185	.20848	.20965	.70131	.00393	.5544	.00004
3.80	58.991	105.22	40.498	.22706	.22831	.75740	.00425	.5495	.00005
4.00	56.985	101.64	43.932	.24631	.24766	.81502	.00457	.5448	.00006
4.20	55.123	98.317	47.484	.26623	.26767	.87418	.00490	.5404	.00007
4.40	53.393	95.231	51.152	.28679	.28834	.93487	.00524	.5362	.00008
4.60	51.782	92.358	54.940	.30803	.30968	.99706	.00559	.5323	.00009

ARGON

FRACTION ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON LENGTH PAT. LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	50.278	0.5884	0.5915	0.0106	5.286	.00011
5.50	46.918	0.6909	0.6945	0.0123	5.201	.00015
6.00	44.026	0.8005	0.8046	0.0140	5.125	.00020
6.50	41.507	0.9170	0.9217	0.0158	5.058	.00026
7.00	39.290	1.0403	1.0455	0.0178	4.997	.00032
7.50	37.322	1.1703	1.1761	0.0198	4.942	.00040
8.00	35.563	1.3070	1.3134	0.0219	4.891	.00045
8.50	33.980	1.4502	1.4573	0.0240	4.845	.00098
9.00	32.548	1.6000	1.6077	0.0263	4.803	.00132
9.50	31.245	1.7561	1.7645	0.0286	4.764	.00166
10.00	30.054	1.9186	1.9277	0.0310	4.727	.00201
11.00	27.954	2.2624	2.2730	0.0360	4.661	.00330
12.00	26.158	2.6309	2.6430	0.0414	4.603	.00624
13.00	24.604	3.0236	3.0374	0.0470	4.552	.00920
14.00	23.243	3.4402	3.4558	0.0529	4.506	.01219
15.00	22.048	3.8803	3.8977	0.0591	4.465	.01519
16.00	20.978	4.3435	4.3628	0.0656	4.428	.01821
17.00	20.018	4.8236	4.8510	0.0723	4.393	.02125
18.00	19.152	5.3355	5.3619	0.0793	4.362	.02431
19.00	18.366	5.8697	5.8952	0.0866	4.333	.02730
20.00	17.649	6.4230	6.4507	0.0941	4.306	.03048
22.00	16.390	7.5951	7.6276	0.1099	4.258	.03673
24.00	15.317	8.8532	8.8907	0.1267	4.216	.04305
26.00	14.392	1.0196	1.0239	0.1445	4.179	.04709
28.00	13.585	1.1621	1.1670	0.1632	4.146	.04878
30.00	12.874	1.3128	1.3183	0.1828	4.117	.05053
32.00	12.244	1.4716	1.4776	0.2033	4.090	.05236
34.00	11.679	1.6382	1.6449	0.2247	4.065	.05424
36.00	11.172	1.8127	1.8201	0.2470	4.043	.05619
38.00	10.712	1.9949	2.0029	0.2701	4.023	.05820
40.00	10.293	2.1847	2.1935	0.2941	4.004	.06025
45.00	9.3964	2.6918	2.7025	0.3575	3.962	.06560
50.00	8.6636	3.2445	3.2573	0.4259	3.927	.07121
55.00	8.0527	3.8414	3.8564	0.4989	3.897	.07708
59.00	7.5351	4.4813	4.4987	0.5765	3.871	.08321
65.00	7.0906	5.1632	5.1831	0.6584	3.849	.08957
70.00	6.7046	5.8861	5.9087	0.7446	3.829	.09618
75.00	6.3661	6.6489	6.6744	0.8348	3.811	.10296
80.00	6.0667	7.4508	7.4792	0.9290	3.795	.10990
90.00	5.5606	9.1684	9.2031	1.1288	3.767	.12415

ARGON

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE		PATH LENGTH GM/CM2		PATH LENGTH SIRAGGLING GM/CM2		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	METER	GM/CM2	METER	GM/CM2	METER PERCENT		
100.00	5.1490	11.032	61.855	11.074	62.087	.13429	.75294	.3744	.13875
110.00	4.8073	13.037	73.092	13.085	73.365	.15707	.88062	.3724	.15376
120.00	4.5192	15.176	85.086	15.232	85.402	.18112	1.0155	.3707	.16924
130.00	4.2727	17.445	97.806	17.509	98.169	.20639	1.1572	.3692	.18511
140.00	4.0594	19.838	111.23	19.912	111.64	.23282	1.3053	.3679	.20125
150.00	3.8731	22.352	125.32	22.435	125.78	.26033	1.4596	.3667	.21760
160.00	3.7089	24.982	140.07	25.074	140.58	.28888	1.6197	.3657	.23415
170.00	3.5630	27.724	155.44	27.826	156.01	.31842	1.7853	.3648	.25091
180.00	3.4326	30.574	171.42	30.686	172.05	.34890	1.9562	.3639	.26783
190.00	3.3154	33.529	187.98	33.651	188.67	.38028	2.1321	.3631	.28483
200.00	3.2094	36.584	205.12	36.717	205.86	.41251	2.3128	.3624	.30188
210.00	3.1132	39.737	222.79	39.882	223.60	.44556	2.4981	.3618	.31896
220.00	3.0254	42.985	241.00	43.141	241.87	.47939	2.6878	.3611	.33603
230.00	2.9450	46.324	259.72	46.491	260.66	.51397	2.8816	.3606	.35308
240.00	2.8711	49.751	278.94	49.931	279.95	.54926	3.0795	.3600	.37005
250.00	2.8029	53.264	298.63	53.457	299.71	.58523	3.2812	.3595	.38692
260.00	2.7399	56.861	318.80	57.066	319.95	.62185	3.4865	.3590	.40367
270.00	2.6815	60.537	339.41	60.755	340.63	.65910	3.6953	.3586	.42033
280.00	2.6272	64.292	350.46	64.523	361.76	.69695	3.9076	.3581	.43684
290.00	2.5765	68.123	381.94	68.367	383.31	.73538	4.1230	.3577	.45320
300.00	2.5292	72.027	403.83	72.285	405.28	.77436	4.3415	.3570	.46938
310.00	2.4850	76.002	426.11	76.274	427.64	.81387	4.5631	.3569	.48535
320.00	2.4435	80.046	448.79	80.333	450.40	.85389	4.7874	.3566	.50108
330.00	2.4045	84.158	471.84	84.458	473.53	.89439	5.0145	.3562	.51660
340.00	2.3678	88.334	495.26	88.650	497.03	.93537	5.2443	.3559	.53185
350.00	2.3333	92.574	519.03	92.904	520.88	.97680	5.4766	.3555	.54684
360.00	2.3006	96.876	543.15	97.221	545.08	1.0187	5.7113	.3552	.56158
370.00	2.2698	101.24	567.60	101.60	569.62	1.0610	5.9484	.3549	.57609
380.00	2.2406	105.66	592.37	106.03	594.48	1.1036	6.1877	.3545	.59036
390.00	2.2129	110.13	617.47	110.52	619.66	1.1467	6.4292	.3542	.60439
400.00	2.1867	114.66	642.87	115.07	645.15	1.1902	6.6729	.3539	.61815
410.00	2.1617	119.25	668.57	119.67	670.94	1.2340	6.9185	.3536	.63161
420.00	2.1380	123.88	694.56	124.32	697.02	1.2781	7.1661	.3533	.64474
430.00	2.1155	128.57	720.83	129.02	723.38	1.3226	7.4155	.3530	.65755
440.00	2.0940	133.30	747.38	133.77	750.02	1.3675	7.6668	.3528	.67001
450.00	2.0735	138.08	774.19	138.57	776.93	1.4126	7.9199	.3525	.68214
460.00	2.0539	142.91	801.27	143.42	804.10	1.4580	8.1746	.3522	.69394
470.00	2.0352	147.79	828.60	148.31	831.52	1.5037	8.4300	.3519	.70540
480.00	2.0173	152.71	856.17	153.25	859.19	1.5497	8.6889	.3516	.71654
490.00	2.0002	157.67	883.99	158.22	887.10	1.5960	8.9483	.3514	.72734

# ARGON

PROCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GH/CM2	KEV/CM	GH/CM2	METER	GH/CM2	METER	GH/CM2	METER		
500.00	1.9839	3.5384	162.67	912.04	163.24	915.25	1.6426	9.2093	.3511	.73782
510.00	1.9682	3.5105	167.71	940.31	168.30	943.62	1.6094	9.4716	.3568	.74797
520.00	1.9532	3.4836	172.80	968.81	173.41	972.22	1.7364	9.7354	.3506	.75781
530.00	1.9387	3.4579	177.92	997.53	178.54	1001.0	1.7837	10.000	.3503	.76733
540.00	1.9249	3.4332	183.08	1026.5	183.72	1030.1	1.8312	10.267	.3500	.77655
550.00	1.9116	3.4095	188.27	1055.6	188.93	1059.3	1.8789	10.534	.3497	.78546
560.00	1.8988	3.3867	193.50	1084.9	194.18	1088.7	1.9269	10.803	.3495	.79407
570.00	1.8865	3.3647	198.77	1114.4	199.47	1118.3	1.9750	11.073	.3492	.80239
580.00	1.8747	3.3436	204.07	1144.1	204.78	1148.2	2.0234	11.344	.3489	.81043
590.00	1.8632	3.3233	209.40	1174.0	210.14	1178.2	2.0720	11.617	.3487	.81819
600.00	1.8523	3.3038	214.77	1204.1	215.52	1208.3	2.1207	11.890	.3484	.82567
620.00	1.8315	3.2667	225.59	1264.8	226.38	1269.2	2.2188	12.440	.3479	.83984
640.00	1.8122	3.2323	236.53	1326.1	237.36	1330.8	2.3175	12.993	.3474	.85300
660.00	1.7943	3.2002	247.59	1388.1	248.45	1393.0	2.4169	13.551	.3468	.86519
680.00	1.7775	3.1703	258.75	1450.7	259.65	1455.8	2.5169	14.112	.3463	.87648
700.00	1.7618	3.1423	270.01	1513.9	270.95	1519.1	2.6176	14.676	.3458	.88692
720.00	1.7471	3.1162	281.38	1577.6	282.35	1583.0	2.7187	15.243	.3452	.89655
740.00	1.7334	3.0917	292.83	1641.8	293.84	1647.5	2.8204	15.813	.3447	.90543
760.00	1.7205	3.0687	304.37	1706.5	305.43	1712.4	2.9226	16.386	.3442	.91361
780.00	1.7084	3.0471	316.00	1771.7	317.09	1777.8	3.0253	16.962	.3436	.92113
800.00	1.6971	3.0269	327.71	1837.4	328.84	1843.7	3.1285	17.540	.3431	.92805
820.00	1.6864	3.0078	339.50	1903.4	340.66	1910.0	3.2320	18.121	.3426	.93439
840.00	1.6763	2.9899	351.35	1969.9	352.56	1976.7	3.3360	18.704	.3420	.94022
860.00	1.6668	2.9729	363.28	2036.8	364.53	2043.8	3.4403	19.289	.3415	.94555
880.00	1.6579	2.9570	375.28	2104.0	376.56	2111.2	3.5451	19.876	.3409	.95044
900.00	1.6494	2.9419	387.34	2171.7	388.66	2179.1	3.6502	20.465	.3404	.95490
920.00	1.6415	2.9277	399.46	2239.6	400.83	2247.3	3.7556	21.056	.3398	.95899
940.00	1.6340	2.9143	411.65	2308.0	413.05	2315.8	3.8613	21.649	.3392	.96272
960.00	1.6268	2.9016	423.91	2376.7	425.35	2384.8	3.9674	22.244	.3385	.96613
1000.00	1.6137	2.8783	448.69	2515.7	450.21	2524.2	4.1805	23.438	.3368	.97208

THE ELECTRON DENSITY OF ARGON IS 2.715E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.143 BEV, AND THE MINIMUM ENERGY LOSS IS 1.5075 MEV/GM/CM2

ADJUSTED  
ONIZATIONAL  
OTENTIAL  
61.00

ATOMIC  
WEIGHT  
9.0122

TONS/  
LECULE

ATOMIC  
NUMBER

# 3B ELEMENT

DENSITY = 1.8200 GM/CM3

144

# BERYLLIUM

PRCTCN ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2 CM	PROTON PATH LENGTH GM/CM2 CM	PATH LENGTH STRAGGLING GM/CM2 CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	66.375	120.80	.04285	.02355	.00063	.00687
5.50	61.527	111.98	.05074	.02788	.00073	.01098
6.00	57.394	104.46	.05909	.03251	.00085	.01506
6.50	53.826	97.963	.06816	.03745	.00097	.01911
7.00	50.711	92.295	.07764	.04271	.00109	.02315
7.50	47.968	87.301	.08777	.04828	.00123	.02716
8.00	45.530	82.865	.09846	.05417	.00137	.03117
8.50	43.358	78.897	.10971	.06035	.00151	.03516
9.00	41.387	75.324	.12151	.06684	.00166	.03913
9.50	39.609	72.088	.13384	.07363	.00182	.04310
10.00	37.991	69.143	.14672	.08071	.00199	.04705
11.00	35.153	63.979	.17408	.09576	.00234	.05493
12.00	32.745	59.595	.20354	.11184	.00271	.06278
13.00	30.672	55.823	.23509	.12917	.00310	.07060
14.00	28.868	52.540	.26867	.14779	.00352	.07839
15.00	27.283	49.656	.30428	.16737	.00397	.08615
16.00	25.879	47.100	.34189	.18806	.00443	.09388
17.00	24.625	44.818	.38190	.20983	.00491	.10159
18.00	23.499	42.767	.42348	.23263	.00542	.10928
19.00	22.480	40.914	.46700	.25659	.00595	.11693
20.00	21.555	39.230	.51244	.28156	.00650	.12457
22.00	19.936	36.282	.60901	.33462	.00766	.13975
24.00	18.566	33.790	.71304	.39178	.00890	.15483
26.00	17.390	31.649	.82441	.45297	.01022	.16963
28.00	16.369	29.791	.94204	.51814	.01161	.18404
30.00	15.473	28.161	1.0676	.58662	.01308	.19854
32.00	14.681	26.719	1.2003	.65949	.01463	.21311
34.00	13.975	25.435	1.3398	.73616	.01625	.22775
36.00	13.342	24.282	1.4862	.81658	.01793	.24245
38.00	12.770	23.242	1.6393	.90071	.01969	.25719
40.00	12.252	22.296	1.7991	.98850	.02152	.27199
45.00	11.143	20.280	2.2272	1.2237	.02636	.28112
50.00	10.242	18.640	2.6953	1.4809	.03164	.29336
55.00	9.4934	17.278	3.2023	1.7595	.03729	.30381
60.00	8.8620	16.129	3.7473	2.0590	.04332	.31157
65.00	8.3216	15.145	4.3293	2.3788	.04971	.31960
70.00	7.8537	14.294	4.9476	2.7184	.05645	.32786
75.00	7.4424	13.549	5.6012	3.0776	.06353	.33630
80.00	7.0833	12.892	6.2893	3.4557	.07094	.34489
90.00	6.4747	11.784	7.7666	4.2673	.08671	.36237



# BERYLLIUM

PROTON ENRGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
100.00	5.9814	9.3737	5.1504	9.3826	5.1553	.10368	.05697	1.105	.28004
110.00	5.5732	11.106	6.1019	11.116	6.1077	.12180	.06692	1.096	.29808
120.00	5.2297	12.957	7.1195	12.970	7.1262	.14099	.07746	1.087	.31672
130.00	4.9366	14.925	8.2015	14.939	8.2082	.16120	.08857	1.079	.33584
140.00	4.6835	17.004	9.3427	17.020	9.3515	.18238	.10021	1.072	.35531
150.00	4.4627	19.190	10.544	19.208	10.554	.20449	.11236	1.065	.37541
160.00	4.2683	21.480	11.802	21.500	11.813	.22747	.12499	1.058	.39480
170.00	4.0960	23.870	13.116	23.893	13.128	.25130	.13808	1.052	.41451
180.00	3.9421	26.357	14.482	26.382	14.496	.27592	.15160	1.046	.43406
190.00	3.8039	28.938	15.900	28.965	15.915	.30131	.16555	1.040	.45339
200.00	3.6791	31.609	17.368	31.639	17.384	.32742	.17990	1.035	.47244
210.00	3.5658	34.369	18.884	34.400	18.901	.35423	.19463	1.030	.49093
220.00	3.4625	37.212	20.446	37.247	20.465	.38171	.20973	1.025	.50863
230.00	3.3680	40.139	22.054	40.175	22.074	.40983	.22518	1.020	.52553
240.00	3.2812	43.145	23.706	43.184	23.728	.43856	.24097	1.016	.54161
250.00	3.2012	46.228	25.400	46.270	25.423	.46787	.25707	1.011	.55687
260.00	3.1273	49.386	27.135	49.431	27.160	.49775	.27349	1.007	.57155
270.00	3.0588	52.617	28.910	52.665	28.937	.52817	.29020	1.003	.58589
280.00	2.9951	55.918	30.724	55.969	30.752	.55911	.30720	.9990	.59986
290.00	2.9358	59.288	32.576	59.341	32.605	.59054	.32447	.9952	.61345
300.00	2.8804	62.724	34.464	62.781	34.495	.62246	.34201	.9915	.62666
310.00	2.8286	66.224	36.387	66.284	36.420	.65483	.35980	.9879	.63979
320.00	2.7800	69.787	38.345	69.851	38.379	.68765	.37783	.9845	.65311
330.00	2.7343	73.412	40.336	73.478	40.372	.72089	.39609	.9811	.66658
340.00	2.6914	77.095	42.360	77.164	42.398	.75455	.41459	.9778	.68015
350.00	2.6508	80.836	44.415	80.909	44.455	.78860	.43330	.9747	.69376
360.00	2.6126	84.633	46.501	84.709	46.543	.82303	.45222	.9716	.70731
370.00	2.5764	88.484	48.617	88.563	48.661	.85784	.47134	.9686	.72069
380.00	2.5422	92.388	50.763	92.471	50.808	.89300	.49066	.9657	.73387
390.00	2.5097	96.344	52.936	96.436	52.984	.92851	.51017	.9629	.74682
400.00	2.4789	100.35	55.137	100.44	55.187	.96436	.52987	.9601	.75952
410.00	2.4496	104.40	57.365	104.50	57.416	1.0005	.54974	.9575	.77182
420.00	2.4217	108.51	59.619	108.60	59.672	1.0370	.56978	.9549	.78360
430.00	2.3952	112.66	61.899	112.76	61.954	1.0738	.58999	.9523	.79488
440.00	2.3699	116.85	64.203	116.95	64.260	1.1109	.61037	.9498	.80567
450.00	2.3457	121.09	66.531	121.19	66.591	1.1482	.63089	.9474	.81597
460.00	2.3227	125.37	68.883	125.48	68.945	1.1859	.65157	.9451	.82581
470.00	2.3006	129.69	71.258	129.81	71.322	1.2238	.67240	.9428	.83520
480.00	2.2796	134.05	73.656	134.17	73.721	1.2619	.69337	.9405	.84414
490.00	2.2594	138.46	76.075	138.58	76.142	1.3004	.71448	.9384	.85266

# BERYLLIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.2400	142.90	143.02	78.595	1.3390	.73572	.9362	.86077
510.00	2.2214	147.38	147.51	81.048	1.3779	.75710	.9341	.86848
520.00	2.2036	151.89	152.03	83.531	1.4170	.77860	.9321	.87581
530.00	2.1865	156.44	156.58	86.034	1.4564	.80022	.9301	.88278
540.00	2.1701	161.03	161.17	88.557	1.4960	.82197	.9282	.88939
550.00	2.1543	165.65	165.80	91.098	1.5358	.84383	.9263	.89566
560.00	2.1391	170.31	170.46	93.657	1.5758	.86580	.9244	.90161
570.00	2.1245	174.99	175.15	96.235	1.6160	.88789	.9226	.90725
580.00	2.1104	179.71	179.87	98.830	1.6563	.91008	.9209	.91259
590.00	2.0968	184.46	184.62	101.44	1.6969	.93238	.9191	.91765
600.00	2.0837	189.24	189.41	104.07	1.7377	.95478	.9174	.92243
620.00	2.0589	198.89	199.06	109.38	1.8198	.99988	.9142	.93124
640.00	2.0358	208.65	208.83	114.74	1.9025	1.0454	.9110	.93910
660.00	2.0142	218.52	218.71	120.17	1.9860	1.0912	.9080	.94611
680.00	1.9940	228.49	228.69	125.65	2.0700	1.1374	.9052	.95236
700.00	1.9750	238.56	238.77	131.19	2.1547	1.1839	.9024	.95791
720.00	1.9573	248.73	248.94	136.78	2.2399	1.2307	.8998	.96285
740.00	1.9406	258.91	259.21	142.42	2.3257	1.2779	.8972	.96722
760.00	1.9249	269.32	269.55	148.11	2.4120	1.3253	.8948	.97110
780.00	1.9101	279.75	279.98	153.84	2.4988	1.3730	.8925	.97453
800.00	1.8961	290.25	290.49	159.61	2.5861	1.4210	.8903	.97757
820.00	1.8830	300.82	301.08	165.43	2.6739	1.4692	.8881	.98025
840.00	1.8706	311.47	311.74	171.28	2.7621	1.5177	.8860	.98262
860.00	1.8588	322.19	322.47	177.18	2.8508	1.5664	.8841	.98471
880.00	1.8477	332.98	333.26	183.11	2.9399	1.6153	.8822	.98655
900.00	1.8371	343.83	344.12	189.08	3.0294	1.6645	.8803	.98817
920.00	1.8271	354.74	355.04	195.08	3.1192	1.7139	.8786	.98960
940.00	1.8176	365.72	366.03	201.12	3.2095	1.7635	.8768	.99086
960.00	1.8086	376.77	377.08	207.19	3.3001	1.8133	.8752	.99197
1000.00	1.7929	399.10	399.43	219.47	3.4825	1.9134	.8719	.99380

THE ELECTRON DENSITY OF BERYLLIUM IS 2.674E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.332 BEV, AND THE MINIMUM ENERGY LOSS IS 1.6236 MEV/GM/CM2

# BISMUTH

ATOMIC  
NUMBER  
83

ELEMENT  
BI

ATOMS/  
MOLECULE  
1

ATOMIC  
WEIGHT  
208.98

ADJUSTED  
IONIZATION  
POTENTIAL  
820.1

DENSITY = 9.8000 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE MM	PROTON PATH LENGTH MM	MG/CM2	PATH LENGTH STRAGGLING MM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	122.22	1197.8	1.3067	.00133	1.3827	.00141	.07093	5.496
.15	127.84	1252.9	1.7020	.00174	1.7826	.00182	.08362	4.522
.20	126.44	1239.1	2.0654	.00213	2.1758	.00222	.09400	4.155
.30	113.48	1112.1	2.8906	.00295	3.0075	.00307	.11557	3.885
.40	100.66	980.63	3.7980	.00388	3.9474	.00403	.14411	3.785
.50	90.545	887.34	4.8130	.00491	4.9996	.00510	.17767	3.732
.60	82.849	811.92	5.9273	.00605	6.1547	.00628	.21438	3.695
.70	77.276	757.31	7.1331	.00728	7.4043	.00756	.25316	3.663
.80	71.177	697.54	8.4348	.00861	8.7526	.00893	.29438	3.632
.90	67.176	658.32	9.8304	.01003	10.198	.01041	.33793	3.602
1.00	63.165	619.01	11.314	.01155	11.734	.01197	.38311	3.573
1.20	58.228	570.63	14.504	.01580	15.033	.01534	.47590	3.518
1.40	54.128	530.46	17.954	.01832	18.599	.01898	.56994	3.466
1.60	50.676	496.63	21.656	.02210	22.421	.02288	.66688	3.415
1.80	47.729	467.74	25.661	.02612	26.492	.02703	.77004	3.365
2.00	45.254	443.49	29.775	.03038	30.797	.03143	.87824	3.318
2.20	43.019	421.59	34.171	.03487	35.327	.03605	.99080	3.273
2.40	41.040	402.19	38.796	.03959	40.091	.04091	1.1074	3.230
2.60	39.252	384.67	43.639	.04453	45.077	.04600	1.2280	3.190
2.80	37.720	369.75	48.690	.04968	50.274	.05130	1.3514	3.151
3.00	36.338	356.11	53.942	.05504	55.677	.05681	1.4775	3.115
3.20	35.062	343.61	59.394	.06061	61.282	.06253	1.6063	3.080
3.40	33.885	332.07	65.046	.06637	67.096	.06846	1.7377	3.047
3.60	32.798	321.42	70.891	.07234	73.095	.07459	1.8717	3.016
3.80	31.790	311.54	76.919	.07849	79.286	.08090	2.0083	2.986
4.00	30.851	302.34	83.134	.08483	85.668	.08742	2.1474	2.959
4.20	29.976	293.76	89.550	.09138	92.254	.09414	2.2892	2.931
4.40	29.157	285.73	96.133	.09810	99.016	.10103	2.4334	2.906
4.60	28.389	278.21	102.91	.10501	105.97	.10813	2.5802	2.881
4.80	27.666	271.15	109.87	.11212	113.11	.11541	2.7295	2.857

# BISMUTH

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	GM/CM2	PATH LENGTH STRAGGLING CM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	26.990	11701	12042	.01229	.00288	2.393	2.835	0.
5.50	25.456	13562	13951	.01424	.00327	2.345	2.783	0.
6.00	24.116	15533	15970	.01630	.00368	2.301	2.736	0.
6.50	22.930	17609	18097	.01847	.00409	2.263	2.693	0.
7.00	21.851	19791	20330	.02075	.00453	2.227	2.654	0.
7.50	20.925	22077	22670	.02313	.00498	2.196	2.618	0.
8.00	20.085	24459	25108	.02562	.00545	2.169	2.585	0.
8.50	19.322	26943	27649	.02821	.00593	2.144	2.554	0.
9.00	18.624	29522	30287	.03090	.00643	2.122	2.526	0.
9.50	17.984	32193	33019	.03369	.00694	2.102	2.499	0.
10.00	17.394	34958	35845	.03658	.00747	2.084	2.475	.00001
11.00	16.340	40767	41782	.04263	.00857	2.050	2.430	.00002
12.00	15.425	46936	48085	.04907	.00971	2.020	2.390	.00004
13.00	14.631	53456	54745	.05586	.01091	1.992	2.354	.00007
14.00	13.991	60302	61736	.06320	.01214	1.966	2.322	.00012
15.00	13.352	67469	69052	.07046	.01340	1.941	2.293	.00019
16.00	12.781	74965	76703	.07827	.01472	1.919	2.266	.00027
17.00	12.264	82803	84702	.08643	.01608	1.898	2.241	.00038
18.00	11.793	90960	93024	.09492	.01748	1.879	2.218	.00051
19.00	11.362	99422	10166	.10373	.01892	1.861	2.198	.00067
20.00	10.967	10748	11060	.11286	.02040	1.845	2.177	.00084
22.00	10.267	12928	13211	.12811	.02349	1.814	2.142	.00126
24.00	9.6643	14641	14956	.15261	.02672	1.787	2.111	.00176
26.00	9.1392	16730	17071	.17434	.03011	1.762	2.083	.00270
28.00	8.6770	18935	19322	.19728	.03363	1.740	2.058	.00409
30.00	8.2665	21252	21686	.22136	.03730	1.719	2.036	.00552
32.00	7.8993	23685	24172	.24665	.04110	1.700	2.015	.00702
34.00	7.5672	26224	26760	.27305	.04503	1.683	1.997	.00856
36.00	7.2705	28873	29463	.30058	.04910	1.667	1.980	.01015
38.00	7.0000	31626	32272	.32918	.05328	1.652	1.964	.01179
40.00	6.7683	34478	35164	.35881	.05757	1.637	1.950	.01348
45.00	6.2266	42057	42915	.43755	.06877	1.604	1.918	.01786
50.00	5.7809	510246	51271	.52259	.08076	1.577	1.891	.02248
55.00	5.4051	59050	60255	.61402	.09348	1.553	1.868	.02734
60.00	5.0840	68428	69825	.71139	.10690	1.533	1.848	.03244
65.00	4.8060	79373	79973	.81464	.12098	1.515	1.830	.03776
70.00	4.5628	90871	90684	.92361	.13570	1.499	1.815	.04330
75.00	4.3481	99921	10196	1.0154	.15104	1.484	1.801	.04903
80.00	4.1574	11148	11376	1.1583	.16696	1.471	1.789	.05494
90.00	3.8324	13609	13886	1.4136	.20049	1.447	1.768	.06722

# BISMUTH

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	CH	PROTON PATH LENGTH GM/CM2	CH	GM/CM2	PATH LENGTH STRAGGLING CM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	3.5657	34.944	16.271	1.6603	16.561	1.6899	.23614	.02410	1.426	.08004
110.00	3.3429	32.760	19.121	1.9511	19.459	1.9856	.27380	.02794	1.407	.09336
120.00	3.1547	30.916	22.151	2.2803	22.539	2.2999	.31330	.03197	1.390	.10719
130.00	2.9928	29.329	25.349	2.5867	25.790	2.6317	.35454	.03618	1.375	.12143
140.00	2.8521	27.950	28.717	2.9303	29.214	2.9810	.39742	.04055	1.360	.13603
150.00	2.7286	26.740	32.244	3.2902	32.799	3.3488	.44185	.04509	1.347	.15092
160.00	2.6194	25.670	35.923	3.6657	36.539	3.7285	.48776	.04977	1.335	.16609
170.00	2.5220	24.716	39.752	4.0563	40.431	4.1256	.53506	.05460	1.323	.18155
180.00	2.4348	23.861	43.724	4.4616	44.468	4.5375	.58370	.05956	1.313	.19724
190.00	2.3561	23.090	47.831	4.8807	48.642	4.9634	.63359	.06465	1.303	.21311
200.00	2.2848	22.391	52.066	5.3129	52.946	5.4027	.68469	.06987	1.293	.22914
210.00	2.2200	21.756	56.436	5.7588	57.389	5.8559	.73693	.07520	1.284	.24523
220.00	2.1607	21.175	60.928	6.2172	63.953	6.3217	.79026	.08064	1.276	.26131
230.00	2.1085	20.663	65.540	6.6877	66.646	6.7600	.84456	.08618	1.267	.27735
240.00	2.0582	20.171	70.260	7.1694	71.437	7.2895	.89976	.09181	1.260	.29330
250.00	2.0119	19.716	75.101	7.6634	76.356	7.7914	.95592	.09754	1.252	.30916
260.00	1.9689	19.295	80.049	8.1683	81.385	8.3046	1.0130	.10337	1.245	.32495
270.00	1.9291	18.905	85.084	8.6821	86.501	8.8267	1.0709	.10928	1.238	.34372
280.00	1.8920	18.541	90.238	9.2080	91.739	9.3611	1.1297	.11528	1.231	.35644
290.00	1.8574	18.202	95.491	9.7439	97.076	9.9057	1.1893	.12136	1.225	.37210
300.00	1.8250	17.885	100.84	10.290	102.51	10.460	1.2496	.12751	1.219	.38766
310.00	1.7948	17.589	106.28	10.845	108.04	11.024	1.3107	.13375	1.213	.40312
320.00	1.7663	17.310	111.81	11.409	113.66	11.598	1.3725	.14005	1.208	.41849
330.00	1.7396	17.048	117.40	11.980	119.34	12.176	1.4349	.14642	1.202	.43375
340.00	1.7134	16.792	123.10	12.561	125.13	12.769	1.4980	.15286	1.197	.44887
350.00	1.6897	16.559	128.89	13.152	131.02	13.369	1.5618	.15937	1.192	.46385
360.00	1.6674	16.340	134.76	13.751	136.98	13.977	1.6262	.16594	1.187	.47864
370.00	1.6462	16.133	140.70	14.357	143.01	14.593	1.6912	.17257	1.183	.49318
380.00	1.6262	15.936	146.71	14.970	149.12	15.216	1.7567	.17925	1.178	.50746
390.00	1.6071	15.750	152.79	15.591	155.30	15.847	1.8227	.18599	1.174	.52149
400.00	1.5891	15.573	158.95	16.220	161.56	16.486	1.8892	.19278	1.169	.53525
410.00	1.5720	15.405	165.25	16.863	167.96	17.139	1.9562	.19961	1.165	.54877
420.00	1.5557	15.246	171.55	17.505	174.36	17.791	2.0237	.20650	1.161	.56206
430.00	1.5402	15.094	177.90	18.153	180.81	18.450	2.0915	.21342	1.157	.57510
440.00	1.5254	14.949	184.32	18.808	187.34	19.116	2.1599	.22039	1.153	.58791
450.00	1.5113	14.811	190.80	19.470	193.92	19.788	2.2286	.22741	1.149	.60047
460.00	1.4979	14.679	197.35	20.137	200.57	20.468	2.2977	.23446	1.146	.61278
470.00	1.4850	14.553	203.95	20.811	207.27	21.150	2.3672	.24155	1.142	.62483
480.00	1.4728	14.433	210.60	21.490	214.04	21.841	2.4371	.24868	1.139	.63663
490.00	1.4610	14.318	217.31	22.175	220.86	22.536	2.5073	.25585	1.135	.64816

# BISMUTH

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	PERCENT		
500.00	1.4498	14.206	224.08	227.73	23.237	2.5779	1.132	1.602	.45944
510.00	1.4390	14.102	230.89	234.65	23.944	2.6480	1.129	1.601	.47046
520.00	1.4287	14.001	237.76	241.63	24.656	2.7200	1.126	1.601	.48122
530.00	1.4188	13.904	244.67	248.65	25.372	2.7915	1.123	1.600	.49172
540.00	1.4092	13.811	251.63	255.72	26.094	2.8633	1.120	1.599	.50196
550.00	1.4001	13.721	258.64	262.84	26.821	2.9354	1.117	1.598	.51194
560.00	1.3913	13.635	265.69	270.01	27.552	3.0078	1.114	1.597	.52167
570.00	1.3829	13.552	272.79	277.22	28.287	3.0804	1.111	1.596	.53114
580.00	1.3748	13.473	279.94	284.47	29.028	3.1533	1.108	1.595	.54036
590.00	1.3670	13.396	287.12	291.77	29.772	3.2264	1.106	1.594	.54933
600.00	1.3595	13.323	294.34	299.11	30.521	3.2998	1.103	1.594	.55805
620.00	1.3453	13.183	308.95	313.94	32.035	3.4473	1.093	1.591	.57477
640.00	1.3320	13.054	323.66	328.89	33.560	3.5956	1.093	1.590	.59054
660.00	1.3198	12.934	338.57	344.03	35.105	3.7447	1.088	1.588	.60539
680.00	1.3083	12.821	353.56	359.26	36.659	3.8946	1.084	1.587	.61936
700.00	1.2976	12.717	368.68	374.62	38.226	4.0452	1.080	1.585	.63247
720.00	1.2876	12.619	383.92	390.10	39.806	4.1965	1.076	1.584	.64477
740.00	1.2783	12.527	399.28	405.70	41.398	4.3484	1.072	1.582	.65629
760.00	1.2695	12.441	414.74	421.40	43.000	4.5009	1.068	1.581	.66706
780.00	1.2613	12.361	430.31	437.22	44.614	4.6540	1.064	1.579	.67712
800.00	1.2536	12.286	445.98	453.13	46.238	4.8076	1.061	1.578	.68750
820.00	1.2464	12.215	461.76	469.15	47.872	4.9617	1.058	1.576	.69825
840.00	1.2396	12.148	477.61	485.25	49.515	5.1162	1.054	1.574	.70940
860.00	1.2332	12.086	493.55	501.44	51.167	5.2713	1.051	1.572	.72097
880.00	1.2272	12.027	509.58	517.72	52.828	5.4267	1.048	1.571	.73181
900.00	1.2216	11.971	525.69	534.07	54.497	5.5826	1.045	1.569	.74254
920.00	1.2162	11.919	541.88	550.51	56.174	5.7389	1.042	1.567	.75360
940.00	1.2112	11.870	558.15	567.02	57.859	5.8955	1.040	1.565	.76421
960.00	1.2063	11.823	574.48	583.60	59.551	6.0525	1.037	1.563	.77440
1000.00	1.1978	11.738	607.45	617.06	62.965	6.3074	1.032	1.555	.79059

THE ELECTRON DENSITY OF BISMUTH IS 2.393E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.914 BEV, AND THE MINIMUM ENERGY LOSS IS 1.1340 MEV/GM/CM2

# BORON

ELEMENT NUMBER 5  
 ATOMIC WEIGHT 10.811  
 ADJUSTED IONIZATION POTENTIAL 67.10  
 ATOMS/MOLECULE 1

DENSITY = 2.3000 GM/CM3

PROCTON ENERGY MEV	ENERGY LOSS MEV/CH	PROTON RANGE MG/CH2	PROTON PATH LENGTH MG/CH2	MG. M2	PATH LENGTH STRAGGLING MM PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	761.40	14434	14525	.00460	.00002	.6253	0.
.15	675.34	21396	21494	.00606	.00003	.4524	0.
.20	600.38	29231	29342	.00769	.00003	.3771	0.
.30	485.19	47782	47929	.01151	.00005	.3074	0.
.40	408.52	70274	70467	.01603	.00007	.2735	0.
.50	356.23	96487	96732	.02113	.00009	.2529	0.
.60	316.74	12623	12655	.02673	.00012	.2388	0.
.70	285.02	15944	15980	.03283	.00014	.2283	0.
.80	261.46	19600	19644	.03939	.00017	.2200	0.
.90	240.89	23575	23625	.04637	.00020	.2134	0.
1.00	220.29	27908	27966	.05397	.00023	.2077	0.
1.20	194.58	37569	37644	.07064	.00031	.1589	0.
1.40	174.83	48412	48506	.08864	.00039	.1222	.00001
1.60	159.11	60404	60518	.10799	.00047	.1869	.00002
1.80	146.24	73511	73646	.12869	.00056	.1825	.00003
2.00	135.48	87708	87865	.15071	.00066	.1786	.00004
2.20	126.34	10298	10316	.17405	.00076	.1755	.00006
2.40	118.46	11931	11952	.19870	.00086	.1727	.00009
2.60	111.50	13669	13692	.22462	.00098	.1701	.00012
2.80	105.22	15513	15539	.25187	.00110	.1679	.00015
3.00	99.924	17461	17490	.28055	.00122	.1658	.00019
3.20	95.177	19510	19542	.31042	.00135	.1639	.00023
3.40	90.899	21657	21693	.34147	.00148	.1623	.00028
3.60	87.021	23902	23940	.37370	.00162	.1608	.00033
3.80	83.489	26246	26288	.40710	.00177	.1593	.00038
4.00	80.258	28688	28734	.44166	.00192	.1580	.00044
4.20	77.289	31221	31270	.47738	.00208	.1567	.00049
4.40	74.551	33855	33908	.51424	.00224	.1556	.00055
4.60	72.017	36577	36634	.55223	.00240	.1545	.00062
4.80	69.665	39400	39461	.59135	.00257	.1535	.00068

BORON

PRCTCN ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM2	HEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	PERCENT		
5.00	67.476	155.20	.04231	.01840	.04237	.01842	.00063	.00027	1.490	.00114
5.50	62.609	144.00	.05009	.02174	.05008	.02177	.00074	.00032	1.472	.00455
6.00	58.453	134.44	.05826	.02533	.05835	.02537	.00085	.00037	1.455	.00795
6.50	54.858	126.17	.06708	.02917	.06718	.02921	.00097	.00042	1.441	.01132
7.00	51.716	118.95	.07646	.03325	.07657	.03329	.00109	.00048	1.428	.01438
7.50	48.944	112.57	.08539	.03756	.08652	.03752	.00123	.00053	1.416	.01803
8.00	46.479	106.90	.09587	.04212	.09701	.04218	.00136	.00059	1.406	.02137
8.50	44.272	101.83	.10788	.04690	.10803	.04697	.00151	.00066	1.396	.02470
9.00	42.283	97.251	.11942	.05192	.11959	.05206	.00166	.00072	1.387	.02802
9.50	40.481	93.105	.13150	.05717	.13168	.05725	.00182	.00079	1.379	.03134
10.00	38.839	89.330	.14409	.06265	.14429	.06273	.00198	.00086	1.371	.03466
11.00	35.958	82.704	.17084	.07428	.17107	.07438	.00232	.00101	1.358	.04127
12.00	33.510	77.072	.19963	.08680	.19990	.08691	.00269	.00117	1.345	.04787
13.00	31.401	72.222	.23044	.10019	.23075	.10033	.00308	.00134	1.334	.05145
14.00	29.565	67.999	.26323	.11445	.26358	.11460	.00349	.00152	1.325	.06103
15.00	27.950	64.286	.29799	.12956	.29839	.12973	.00393	.00171	1.316	.06759
16.00	26.519	60.993	.33469	.14552	.33513	.14571	.00438	.00191	1.307	.07415
17.00	25.240	58.053	.37331	.16231	.37380	.16252	.00486	.00211	1.300	.08070
18.00	24.091	55.409	.41383	.17992	.41437	.18016	.00536	.00233	1.293	.08724
19.00	23.052	53.019	.45622	.19836	.45681	.19861	.00588	.00255	1.286	.09377
20.00	22.107	50.846	.50047	.21760	.50112	.21788	.00642	.00279	1.280	.10029
22.00	20.454	47.044	.59449	.25848	.59525	.25881	.00755	.00328	1.269	.11331
24.00	19.053	43.823	.69576	.30250	.69664	.30289	.00877	.00381	1.259	.12628
26.00	17.851	41.056	.80414	.34963	.80515	.35007	.01007	.00438	1.250	.13395
28.00	16.806	38.654	.91954	.39980	.92069	.40030	.01144	.00497	1.242	.13619
30.00	15.890	36.546	1.0418	.45297	1.0431	.45354	.01288	.00560	1.235	.13851
32.00	15.079	34.681	1.1709	.50911	1.1724	.50974	.01439	.00626	1.228	.14090
34.00	14.356	33.019	1.3068	.56816	1.3084	.56886	.01598	.00695	1.221	.14337
36.00	13.708	31.527	1.4492	.63009	1.4510	.63086	.01763	.00767	1.215	.14589
38.00	13.122	30.181	1.5982	.69467	1.6002	.69572	.01935	.00841	1.209	.14847
40.00	12.591	28.959	1.7537	.76246	1.7558	.76339	.02114	.00919	1.204	.15109
45.00	11.455	26.346	2.1701	.94351	2.1727	.94465	.02590	.01126	1.192	.15781
50.00	10.530	24.220	2.6253	1.1414	2.6284	1.1428	.03105	.01350	1.181	.16468
55.00	9.7631	22.455	3.1183	1.3558	3.1220	1.3574	.03658	.01591	1.172	.17176
60.00	9.1153	20.965	3.6481	1.5861	3.6524	1.5880	.04248	.01847	1.163	.17915
65.00	8.5608	19.690	4.2138	1.8321	4.2188	1.8342	.04873	.02119	1.155	.18679
70.00	8.0805	18.585	4.8146	2.0933	4.8202	2.0958	.05532	.02405	1.148	.19464
75.00	7.6603	17.619	5.4497	2.3694	5.4561	2.3722	.06225	.02706	1.141	.20267
80.00	7.2895	16.766	6.1183	2.6601	6.1254	2.6632	.06949	.03021	1.134	.21083
90.00	6.6645	15.328	7.5533	3.2841	7.5620	3.2878	.08490	.03691	1.123	.22745



BORON

PROTON ENERGY MEV	ENERGY LOSS MEV/CM2	PROTON RANGE CM	PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
			GM/CM2	CH	GM/CM2	CH		
100.00	6.1577	14.163	9.1142	3.9627	.10148	.04412	1.112	.24424
110.00	5.7384	13.198	10.796	4.6939	.11918	.05182	1.103	.26135
120.00	5.3854	12.386	12.594	5.4757	.13792	.05936	1.094	.27896
130.00	5.0841	11.693	14.504	6.3062	.15765	.06855	1.086	.29694
140.00	4.8239	11.095	16.541	7.1918	.17833	.07754	1.078	.31519
150.00	4.5969	10.573	18.645	8.1063	.19991	.08692	1.071	.33360
160.00	4.3971	10.113	20.891	9.0829	.22235	.09667	1.064	.35210
170.00	4.2199	9.7058	23.187	10.081	.24560	.10678	1.058	.37063
180.00	4.0617	9.3418	25.600	11.131	.26962	.11723	1.052	.38912
190.00	3.9195	9.0148	28.105	12.219	.29439	.12800	1.046	.40751
200.00	3.7911	8.7195	30.697	13.346	.31987	.13907	1.041	.42573
210.00	3.6746	8.4515	33.374	14.510	.34603	.15045	1.036	.44365
220.00	3.5684	8.2072	36.133	15.710	.37283	.16210	1.031	.46115
230.00	3.4712	7.9837	38.971	16.944	.40026	.17402	1.026	.47821
240.00	3.3819	7.7783	41.887	18.212	.42827	.18621	1.021	.49478
250.00	3.2996	7.5891	44.878	19.512	.45686	.19864	1.017	.51086
260.00	3.2235	7.4142	47.942	20.844	.48600	.21130	1.013	.52654
270.00	3.1530	7.2520	51.131	22.231	.51566	.22420	1.009	.54192
280.00	3.0875	7.1013	54.277	23.599	.54582	.23732	1.005	.55698
290.00	3.0265	6.9609	57.545	25.020	.57647	.25064	1.001	.57171
300.00	2.9695	6.8298	60.878	26.469	.60759	.26417	.9970	.58609
310.00	2.9162	6.7072	64.273	27.945	.63915	.27789	.9933	.60028
320.00	2.8662	6.5922	67.728	29.447	.67114	.29180	.9898	.61445
330.00	2.8192	6.4842	71.243	30.975	.70354	.30589	.9865	.62855
340.00	2.7751	6.3826	74.814	32.528	.73634	.32015	.9832	.64255
350.00	2.7334	6.2869	78.442	34.105	.76953	.33458	.9800	.65644
360.00	2.6941	6.1965	82.123	35.706	.80308	.34917	.9768	.67018
370.00	2.6570	6.1111	85.857	37.329	.83699	.36391	.9738	.68378
380.00	2.6219	6.0303	89.642	38.975	.87125	.37880	.9709	.69720
390.00	2.5886	5.9537	93.476	40.642	.90583	.39384	.9680	.71042
400.00	2.5570	5.8811	97.359	42.330	.94074	.40902	.9652	.72341
410.00	2.5270	5.8120	101.29	44.039	.97596	.42433	.9625	.73605
420.00	2.4984	5.7464	105.27	45.768	1.0115	.43977	.9598	.74825
430.00	2.4713	5.6839	109.29	47.516	1.0473	.45534	.9573	.75999
440.00	2.4454	5.6244	113.35	49.282	1.0834	.47102	.9547	.77129
450.00	2.4207	5.5676	117.46	51.068	1.1197	.48683	.9523	.78216
460.00	2.3972	5.5135	121.60	52.871	1.1563	.50275	.9499	.79260
470.00	2.3746	5.4617	125.79	54.691	1.1932	.51877	.9475	.80262
480.00	2.3531	5.4122	130.02	56.529	1.2303	.53491	.9452	.81224
490.00	2.3325	5.3648	134.28	58.383	1.2676	.55114	.9430	.82146

# BORON

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PATH LENGTH STRAGGLING GM/CH2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.3128	5.3194	138.58	60.253	138.73	60.317
510.00	2.2939	5.2759	142.92	62.138	143.07	62.205
520.00	2.2757	5.2341	147.29	64.040	147.45	64.108
530.00	2.2582	5.1940	151.70	65.956	151.86	66.026
540.00	2.2415	5.1554	156.14	67.886	156.30	67.958
550.00	2.2254	5.1183	160.61	69.831	160.78	69.905
560.00	2.2098	5.0826	165.12	71.790	165.29	71.866
570.00	2.1949	5.0483	169.65	73.762	169.83	73.840
580.00	2.1805	5.0152	174.22	75.747	174.40	75.827
590.00	2.1667	4.9833	178.82	77.746	179.00	77.828
600.00	2.1533	4.9526	183.44	79.757	183.63	79.841
620.00	2.1279	4.8943	192.77	83.215	192.98	83.903
640.00	2.1043	4.8399	202.22	87.920	202.43	88.012
660.00	2.0822	4.7891	211.76	92.070	211.98	92.167
680.00	2.0616	4.7416	221.40	96.263	221.64	96.364
700.00	2.0422	4.6971	231.14	100.50	231.38	100.60
720.00	2.0241	4.6553	240.97	104.77	241.22	104.88
740.00	2.0070	4.6161	250.88	109.08	251.15	109.19
760.00	1.9909	4.5791	260.88	113.43	261.15	113.54
780.00	1.9758	4.5443	270.96	117.81	271.24	117.93
800.00	1.9615	4.5115	281.11	122.22	281.40	122.35
820.00	1.9480	4.4805	291.33	126.66	291.63	126.80
840.00	1.9353	4.4512	301.62	131.14	301.93	131.27
860.00	1.9233	4.4235	311.98	135.64	312.30	135.78
880.00	1.9118	4.3973	322.40	140.18	322.73	140.32
900.00	1.9010	4.3724	332.89	144.73	333.23	144.88
920.00	1.8908	4.3488	343.44	149.32	343.79	149.47
940.00	1.8810	4.3264	354.04	153.93	354.40	154.09
960.00	1.8718	4.3051	364.71	158.57	365.08	158.73
1000.00	1.8546	4.2657	386.29	167.95	386.68	168.12

THE ELECTRON DENSITY OF BORON IS 2.786E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.317 BEV, AND THE MINIMUM ENERGY LOSS IS 1.6801 MEV/GH/CH2

# CADMIUM

ELEMENT CD  
 ATOMIC NUMBER 48  
 ATOMS/MOLECULE 1  
 ATOMIC WEIGHT 112.40  
 ADJUSTED IONIZATION POTENTIAL 468.0

DENSITY = 8.6500 GM/CM3

PROCTON ENERGY MEV	ENERGY LOSS MEV/GM2	PROTON RANGE HG/CM2	PROTON PATH LENGTH HG/CM2	PATH LENGTH STRAGGLING HG/CM2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	250.93	.79764	.82741	.03928	4.747	3.598	0.
.15	225.31	1.0064	1.0376	.04312	4.156	3.009	0.
.20	203.98	1.2362	1.2707	.04772	3.755	2.717	0.
.30	171.49	1.7627	1.8068	.05945	3.290	2.442	0.
.40	148.78	2.3781	2.4343	.07614	3.128	2.311	0.
.50	132.28	3.0779	3.1492	.09649	3.065	2.233	0.
.60	119.62	3.8581	3.9440	.11938	3.027	2.177	0.
.70	109.59	4.7155	4.8183	.14424	2.994	2.134	0.
.80	102.15	5.6445	5.7654	.17051	2.957	2.097	0.
.90	96.595	6.6312	6.7712	.19730	2.914	2.066	0.
1.00	91.040	7.6784	7.8381	.22479	2.868	2.038	0.
1.20	82.581	9.9468	10.149	.28229	2.782	1.988	0.
1.40	75.981	12.430	12.676	.34220	2.700	1.944	0.
1.60	70.554	15.118	15.411	.40450	2.625	1.905	0.
1.80	66.013	18.001	18.344	.46936	2.559	1.869	0.
2.00	62.183	21.073	21.467	.53814	2.507	1.837	0.
2.20	58.869	24.326	24.774	.61060	2.465	1.807	0.
2.40	55.966	27.757	28.260	.68627	2.428	1.779	0.
2.60	53.545	31.360	31.920	.76472	2.396	1.754	0.
2.80	51.227	35.117	35.736	.84530	2.365	1.731	0.
3.00	49.141	39.043	39.722	.92844	2.337	1.708	0.
3.20	47.250	43.136	43.876	1.0140	2.311	1.688	0.
3.40	45.525	47.389	48.193	1.1019	2.286	1.668	0.
3.60	43.944	51.794	52.663	1.1920	2.264	1.650	0.
3.80	42.488	56.354	57.290	1.2844	2.242	1.633	0.
4.00	41.138	61.072	62.076	1.3788	2.221	1.617	0.
4.20	39.891	65.943	67.016	1.4754	2.202	1.601	0.
4.40	38.730	70.956	72.100	1.5739	2.183	1.587	0.
4.60	37.647	76.129	77.346	1.6745	2.165	1.573	0.
4.80	36.634	81.436	82.726	1.7770	2.148	1.560	0.

# CADMIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	35.684	0.0869	0.0826	0.0188	0.0022	1.547	0.
5.50	33.547	0.1016	0.1020	0.0215	0.0025	1.510	0.
6.00	31.674	0.1163	0.1187	0.0243	0.0028	1.492	0.
6.50	30.035	0.1323	0.1365	0.0272	0.0031	1.469	0.0001
7.00	28.581	0.1491	0.1552	0.0303	0.0035	1.448	0.0001
7.50	27.305	0.1684	0.1750	0.0334	0.0039	1.428	0.0002
8.00	26.154	0.1853	0.1957	0.0366	0.0042	1.411	0.0004
8.50	25.109	0.2040	0.2173	0.0400	0.0046	1.394	0.0005
9.00	24.155	0.2246	0.2399	0.0434	0.0050	1.379	0.0007
9.50	23.281	0.2454	0.2634	0.0469	0.0054	1.365	0.0010
10.00	22.477	0.2671	0.2877	0.0505	0.0058	1.352	0.0013
11.00	21.047	0.3125	0.3130	0.0580	0.0067	1.328	0.0021
12.00	19.819	0.3609	0.3662	0.0659	0.0076	1.307	0.0031
13.00	18.742	0.4129	0.4228	0.0742	0.0086	1.288	0.0044
14.00	17.794	0.4663	0.4766	0.0828	0.0096	1.271	0.0059
15.00	16.947	0.5234	0.5392	0.0918	0.0106	1.256	0.0077
16.00	16.187	0.5832	0.6051	0.1012	0.0117	1.242	0.0097
17.00	15.504	0.6456	0.6741	0.1109	0.0128	1.229	0.0120
18.00	14.876	0.7106	0.7556	0.1210	0.0140	1.217	0.0149
19.00	14.307	0.7785	0.8317	0.1314	0.0152	1.207	0.0207
20.00	13.785	0.8498	0.9110	0.1422	0.0164	1.196	0.0267
22.00	12.860	0.9972	1.0934	0.1648	0.0190	1.178	0.0659
24.00	12.068	1.1567	1.1672	0.1886	0.0218	1.162	0.1063
26.00	11.379	1.3257	1.3372	0.2136	0.0247	1.148	0.1339
28.00	10.775	1.5045	1.5325	0.2399	0.0277	1.136	0.1482
30.00	10.240	1.6930	1.7593	0.2673	0.0309	1.125	0.1632
32.00	9.7629	1.8910	1.9795	0.2959	0.0342	1.114	0.1787
34.00	9.3333	2.0985	2.2108	0.3256	0.0376	1.105	0.1947
36.00	8.9495	2.3153	2.4532	0.3563	0.0412	1.097	0.2113
38.00	8.6007	2.5409	2.7063	0.3881	0.0449	1.089	0.2283
40.00	8.2819	2.7756	2.9698	0.4210	0.0487	1.082	0.2459
45.00	7.5943	3.4005	3.2439	0.5074	0.0587	1.067	0.2916
50.00	7.0280	4.0788	3.9736	0.5999	0.0694	1.054	0.3397
55.00	6.5531	4.8089	4.7656	0.6981	0.0807	1.043	0.3902
60.00	6.1488	5.5895	5.6180	0.8020	0.0927	1.033	0.4433
65.00	5.8002	6.4192	6.5293	0.9112	0.1053	1.025	0.4987
70.00	5.4964	7.2966	7.4978	1.0255	0.1186	1.017	0.5562
75.00	5.2291	8.2206	8.5221	1.1449	0.1324	1.011	0.6156
80.00	4.9920	9.1903	9.6007	1.2691	0.1467	1.005	0.6768
90.00	4.5898	11.262	1.0733	1.5313	0.1770	0.952	0.8037
		11.3020	1.3151		1.346		

# CADMIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
100.00	4.2613	13.504	1.5612	13.639	1.5767	.18111	.02094	1.328	.09355
110.00	3.9677	15.909	1.8392	16.066	1.8574	.21073	.02436	1.312	.10721
120.00	3.7587	18.469	2.1352	18.651	2.1562	.24189	.02796	1.297	.12137
130.00	3.5598	21.121	2.4486	21.388	2.4726	.27447	.03173	1.283	.13595
140.00	3.3872	24.034	2.7785	24.268	2.8056	.30846	.03566	1.271	.15088
150.00	3.2362	27.026	3.1244	27.288	3.1547	.34377	.03974	1.260	.16608
160.00	3.1029	30.155	3.4861	30.445	3.5198	.38033	.04397	1.249	.18154
170.00	2.9844	33.413	3.8627	33.735	3.9000	.41808	.04833	1.239	.19727
180.00	2.8783	36.793	4.2536	37.147	4.2944	.45696	.05283	1.230	.21322
190.00	2.7827	40.295	4.6584	40.681	4.7030	.49691	.05745	1.221	.22932
200.00	2.6963	43.914	5.0767	44.333	5.1252	.53789	.06218	1.213	.24555
210.00	2.6171	47.642	5.5078	48.097	5.5603	.57984	.06704	1.206	.26182
220.00	2.5453	51.483	5.9518	51.973	6.0084	.62277	.07200	1.198	.27806
230.00	2.4795	55.428	6.4078	55.954	6.4687	.66657	.07706	1.191	.29424
240.00	2.4190	59.476	6.8759	60.040	6.9411	.71122	.08222	1.185	.31032
250.00	2.3632	63.618	7.3547	64.221	7.4243	.75667	.08748	1.178	.32627
260.00	2.3115	67.858	7.8449	68.500	7.9190	.80290	.09282	1.172	.34218
270.00	2.2636	72.100	8.3457	72.872	8.4245	.84987	.09825	1.166	.35810
280.00	2.2190	76.611	8.8568	77.334	8.9403	.89755	.10376	1.161	.37401
290.00	2.1775	81.123	9.3783	81.887	9.4667	.94591	.10935	1.155	.38989
300.00	2.1387	85.715	9.9092	86.521	10.002	.99492	.11502	1.150	.40572
310.00	2.1023	90.386	10.449	91.236	10.547	1.0446	.12076	1.145	.42144
320.00	2.0682	95.139	10.999	96.032	11.102	1.0948	.12656	1.140	.43701
330.00	2.0361	99.968	11.557	100.91	11.665	1.1456	.13244	1.135	.45242
340.00	2.0060	104.87	12.124	105.85	12.237	1.1969	.13837	1.131	.46766
350.00	1.9775	109.85	12.699	110.87	12.818	1.2488	.14437	1.126	.48270
360.00	1.9507	114.89	13.282	115.97	13.406	1.3012	.15043	1.122	.49753
370.00	1.9253	120.00	13.873	121.13	14.003	1.3541	.15654	1.118	.51213
380.00	1.9013	125.18	14.472	126.35	14.607	1.4074	.16271	1.114	.52651
390.00	1.8785	130.43	15.078	131.64	15.219	1.4612	.16893	1.110	.54064
400.00	1.8569	135.70	15.688	136.96	15.834	1.5155	.17520	1.106	.55451
410.00	1.8364	141.06	16.308	142.38	16.460	1.5701	.18152	1.103	.56814
420.00	1.8169	146.49	16.935	147.85	17.092	1.6252	.18788	1.099	.58152
430.00	1.7983	151.97	17.568	153.38	17.732	1.6806	.19429	1.096	.59463
440.00	1.7806	157.50	18.209	158.97	18.378	1.7364	.20074	1.092	.60749
450.00	1.7637	163.09	18.855	164.61	19.030	1.7926	.20723	1.089	.62008
460.00	1.7476	168.74	19.507	170.30	19.688	1.8491	.21377	1.086	.63240
470.00	1.7322	174.43	20.166	176.05	20.353	1.9059	.22034	1.083	.64445
480.00	1.7175	180.18	20.830	181.85	21.023	1.9631	.22695	1.080	.65622
490.00	1.7034	185.97	21.499	187.69	21.698	2.0206	.23360	1.077	.66772

# CADMIUM

PRCTCN ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH GM/CM2 CM		PATH LENGTH STRAGGLING GM/CM2 CM		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
500.00	1.6899	191.81	22.174	193.58	22.380	2.0784	.24028	1.074	.67894
510.00	1.6770	197.69	22.855	199.52	23.066	2.1365	.24699	1.071	.68988
520.00	1.6646	203.62	23.540	205.51	23.758	2.1948	.25374	1.068	.70055
530.00	1.6528	209.60	24.231	211.53	24.455	2.2534	.26051	1.065	.71094
540.00	1.6414	215.61	24.926	217.60	25.157	2.3123	.26732	1.063	.72106
550.00	1.6304	221.67	25.626	223.72	25.863	2.3715	.27416	1.060	.73091
560.00	1.6199	227.76	26.331	229.87	26.574	2.4308	.28102	1.057	.74049
570.00	1.6098	233.90	27.040	236.06	27.290	2.4905	.28791	1.055	.74980
580.00	1.6001	240.07	27.754	242.29	28.010	2.5503	.29483	1.053	.75884
590.00	1.5907	246.28	28.472	248.55	28.734	2.6104	.30178	1.050	.76763
600.00	1.5817	252.53	29.194	254.86	29.463	2.6706	.30874	1.048	.77615
620.00	1.5647	265.13	30.650	267.57	30.932	2.7918	.32275	1.043	.79245
640.00	1.5489	277.86	32.122	280.41	32.417	2.9138	.33685	1.039	.80776
660.00	1.5341	290.71	33.609	293.38	33.917	3.0364	.35103	1.035	.82213
680.00	1.5204	303.69	35.109	306.47	35.430	3.1598	.36529	1.031	.83559
700.00	1.5075	316.86	36.632	319.77	36.967	3.2838	.37963	1.027	.84817
720.00	1.4955	330.07	38.158	333.09	38.507	3.4084	.39403	1.023	.85992
740.00	1.4843	343.37	39.696	346.51	40.059	3.5336	.40851	1.020	.87088
760.00	1.4738	356.78	41.246	360.04	41.623	3.6593	.42304	1.016	.88108
780.00	1.4640	370.28	42.807	373.65	43.197	3.7856	.43764	1.013	.89058
800.00	1.4547	383.86	44.377	387.36	44.781	3.9123	.45229	1.010	.89939
820.00	1.4460	397.54	45.958	401.15	46.376	4.0395	.46699	1.007	.90757
840.00	1.4376	411.29	47.548	415.02	47.980	4.1671	.48174	1.004	.91515
860.00	1.4301	425.12	49.146	428.97	49.592	4.2951	.49654	1.001	.92217
880.00	1.4229	439.02	50.754	443.00	51.214	4.4235	.51139	.9985	.92866
900.00	1.4161	452.99	52.369	457.09	52.843	4.5523	.52628	.9959	.93466
920.00	1.4096	467.03	53.992	471.26	54.481	4.6815	.54121	.9934	.94019
940.00	1.4036	481.24	55.635	485.59	56.137	4.8110	.55618	.9908	.94530
960.00	1.3979	495.44	57.276	499.90	57.792	4.9408	.57119	.9883	.94999
1000.00	1.3873	524.22	60.604	528.93	61.148	5.2013	.60131	.9834	.95824

THE ELECTRON DENSITY OF CADMIUM IS 2.573E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.011 BEV, AND THE MINIMUM ENERGY LOSS IS 1.3040 MEV/GM/CM2

# CALCIUM

ELEMENT CA  
ATOMIC NUMBER 20  
ATOMS/MOLECULE 1  
ADJUSTED IONIZATION WEIGHT POTENTIAL 211.3  
ATOMIC WEIGHT 40.080

DENSITY = 1.5500 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE MG/CH2	PROTON PATH LENGTH MM	PROTON PATH LENGTH MG/CH2	PATH LENGTH STRAGGLING MM	PATH LENGTH STRAGGLING PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	494.16	.37621	.00243	.38321	.0010	4.134	1.828	0.
.15	436.16	.48350	.00312	.49084	.0011	3.537	1.496	0.
.20	392.01	.60363	.00389	.61171	.0012	3.166	1.322	0.
.30	320.34	.88402	.00570	.89418	.0016	2.832	1.135	0.
.40	265.61	1.2252	.00790	1.2380	.0022	2.720	1.034	0.
.50	232.60	1.6262	.01049	1.6421	.0028	2.671	.9693	0.
.60	213.40	2.0721	.01337	2.0914	.0035	2.613	.9255	0.
.70	189.70	2.5631	.01654	2.5862	.0043	2.561	.8923	0.
.80	168.71	3.1240	.02015	3.1512	.0052	2.542	.8655	0.
.90	162.87	3.7217	.02401	3.7534	.0061	2.507	.8445	0.
1.00	157.03	4.3434	.02802	4.3796	.0069	2.451	.8271	0.
1.20	140.76	5.6817	.03666	5.7274	.0087	2.349	.7983	0.
1.40	128.23	7.1622	.04621	7.2180	.0106	2.267	.7739	0.
1.60	118.12	8.7784	.05664	8.8451	.0125	2.199	.7532	0.
1.80	109.71	10.526	.06791	10.604	.0146	2.141	.7352	0.
2.00	102.56	12.400	.08000	12.490	.0169	2.093	.7194	0.
2.20	96.390	14.400	.09290	14.502	.0192	2.054	.7053	0.
2.40	90.996	16.524	.10660	16.639	.0217	2.023	.6927	0.
2.60	86.240	18.769	.12109	18.898	.0243	1.996	.6812	0.
2.80	82.028	21.134	.13635	21.277	.0271	1.972	.6708	0.
3.00	78.267	23.616	.15236	23.773	.0299	1.951	.6613	.00001
3.20	74.886	26.214	.16912	26.386	.0329	1.932	.6525	.00001
3.40	71.825	28.927	.18662	29.114	.0359	1.914	.6445	.00001
3.60	69.030	31.752	.20485	31.955	.0391	1.897	.6371	.00001
3.80	66.462	34.689	.22380	34.909	.0424	1.882	.6302	.00002
4.00	64.093	37.736	.24346	37.973	.0457	1.867	.6237	.00003
4.20	61.919	40.896	.26384	41.150	.0492	1.853	.6178	.00003
4.40	59.848	44.161	.28491	44.433	.0528	1.840	.6121	.00004
4.60	58.023	47.536	.30668	47.826	.0564	1.828	.6068	.00005
4.80	56.318	51.020	.32916	51.329	.0601	1.816	.6018	.00006

# CALCIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING CM	GM/CM2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	54.726	84.825	.05493	.03544	.00099	1.805	.5971	.00007
5.50	51.128	79.249	.06439	.04154	.00115	1.778	.5863	.00011
6.00	48.021	74.432	.07406	.04806	.00131	1.754	.5769	.00015
6.50	45.312	70.233	.08473	.05498	.00148	1.733	.5686	.00020
7.00	42.924	66.532	.09601	.06194	.00165	1.713	.5610	.00026
7.50	40.801	63.242	.10791	.06962	.00184	1.694	.5542	.00032
8.00	38.900	60.296	.12039	.07767	.00203	1.678	.5480	.00040
8.50	37.187	57.540	.13348	.08658	.00223	1.662	.5424	.00048
9.00	35.634	55.233	.14795	.09545	.00244	1.648	.5372	.00057
9.50	34.219	53.040	.16227	.10469	.00265	1.634	.5324	.00067
10.00	32.925	51.033	.17717	.11430	.00287	1.622	.5279	.00078
11.00	30.639	47.490	.20759	.13463	.00334	1.599	.5199	.00102
12.00	28.682	44.457	.24243	.15641	.00383	1.579	.5130	.00145
13.00	26.986	41.828	.27692	.17961	.00434	1.561	.5068	.00195
14.00	25.501	39.526	.31495	.20422	.00489	1.544	.5013	.00258
15.00	24.188	37.491	.35504	.23020	.00546	1.530	.4963	.00332
16.00	23.019	35.679	.39921	.25755	.00605	1.516	.4919	.00428
17.00	21.970	34.053	.44369	.28625	.00667	1.503	.4878	.00536
18.00	21.023	32.586	.49024	.31628	.00731	1.492	.4841	.00679
19.00	20.163	31.253	.53882	.34762	.00798	1.481	.4807	.00858
20.00	19.380	30.040	.58942	.38027	.00867	1.471	.4775	.01071
22.00	18.003	27.905	.69657	.44940	.01012	1.453	.4719	.01333
24.00	16.830	25.086	.81155	.52358	.01166	1.436	.4669	.01611
26.00	15.817	24.516	.93420	.60271	.01328	1.422	.4626	.01906
28.00	14.933	23.147	1.0595	.68671	.01499	1.409	.4588	.02210
30.00	14.155	21.940	1.1965	.77550	.01679	1.397	.4553	.02521
32.00	13.464	20.869	1.3409	.86900	.01867	1.386	.4522	.02839
34.00	12.845	19.910	1.4923	.96715	.02062	1.376	.4494	.03163
36.00	12.289	19.047	1.6509	1.0699	.02266	1.366	.4468	.03493
38.00	11.785	18.266	1.8164	1.1771	.02477	1.358	.4445	.03829
40.00	11.326	17.556	1.9389	1.2888	.02696	1.349	.4423	.04170
45.00	10.342	16.030	2.4495	1.5803	.03275	1.331	.4375	.05693
50.00	9.5360	14.781	2.9514	1.9124	.03899	1.315	.4335	.06243
55.00	8.8653	13.741	3.4934	2.2538	.04565	1.301	.4301	.06819
60.00	8.2969	12.860	4.0744	2.6287	.05273	1.289	.4272	.07422
65.00	7.8086	12.103	4.6935	3.0380	.06020	1.277	.4246	.08048
70.00	7.3845	11.446	5.3496	3.4660	.06805	1.267	.4224	.08695
75.00	7.0122	10.869	6.0419	3.9144	.07628	1.257	.4203	.09361
80.00	6.6831	10.359	6.7696	4.3859	.08486	1.248	.4185	.10042
90.00	6.1266	9.4962	8.3281	5.3954	.10306	1.232	.4154	.11442



# CALCIUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
100.00	5.6738	8.7944	10.019	6.4640	10.061	6.4908	.12256	.07907	1.218	.12878
110.00	5.2980	8.2119	11.837	7.6370	11.886	7.6685	.14329	.09245	1.206	.14354
120.00	4.9808	7.7203	13.772	8.8888	13.834	8.9253	.16519	.10658	1.194	.15881
130.00	4.7096	7.2998	15.835	10.216	15.900	10.258	.18819	.12141	1.184	.17449
140.00	4.4748	6.9360	18.006	11.617	18.079	11.664	.21224	.13693	1.174	.19049
150.00	4.2697	6.6181	20.286	13.088	20.368	13.141	.23727	.15308	1.165	.20672
160.00	4.0889	6.3378	22.671	14.626	22.762	14.685	.26325	.16984	1.157	.22318
170.00	3.9283	6.0889	25.157	16.230	25.258	16.296	.29012	.18717	1.149	.23987
180.00	3.7848	5.8664	27.741	17.897	27.852	17.969	.31785	.20506	1.141	.25672
190.00	3.6556	5.6663	30.419	19.625	30.542	19.704	.34630	.22347	1.134	.27368
200.00	3.5389	5.4853	33.189	21.412	33.323	21.498	.37570	.24239	1.127	.29070
210.00	3.4329	5.3210	36.048	23.257	36.192	23.350	.40575	.26178	1.121	.30775
220.00	3.3362	5.1711	38.992	25.156	39.148	25.256	.43652	.28162	1.115	.32481
230.00	3.2476	5.0338	42.018	27.109	42.186	27.217	.46795	.30191	1.109	.34183
240.00	3.1662	4.9077	45.125	29.113	45.305	29.229	.50004	.32261	1.104	.35877
250.00	3.0912	4.7913	48.310	31.168	48.502	31.292	.53274	.34371	1.098	.37561
260.00	3.0218	4.6837	51.569	33.271	51.774	33.403	.56604	.36519	1.093	.39235
270.00	2.9574	4.5840	54.902	35.421	55.120	35.561	.59990	.38703	1.088	.40917
280.00	2.8976	4.4912	58.305	37.616	58.536	37.765	.63431	.40923	1.084	.42551
290.00	2.8418	4.4048	61.777	39.866	62.022	40.014	.66924	.43177	1.079	.44189
300.00	2.7897	4.3240	65.315	42.139	65.574	42.306	.70467	.45463	1.075	.45809
310.00	2.7409	4.2484	68.918	44.463	69.190	44.639	.74058	.47780	1.070	.47410
320.00	2.6952	4.1776	72.583	46.828	72.870	47.013	.77696	.50126	1.066	.48989
330.00	2.6523	4.1110	76.309	49.232	76.610	49.426	.81377	.52501	1.062	.50543
340.00	2.6118	4.0483	80.094	51.674	80.410	51.877	.85102	.54904	1.058	.52072
350.00	2.5737	3.9893	83.937	54.153	84.267	54.366	.88867	.57333	1.055	.53575
360.00	2.5378	3.9336	87.835	56.668	88.180	56.890	.92672	.59788	1.051	.55054
370.00	2.5038	3.8809	91.787	59.217	92.148	59.450	.96514	.62257	1.047	.56512
380.00	2.4716	3.8310	95.791	61.801	96.168	62.044	1.0039	.64770	1.044	.57948
390.00	2.4412	3.7838	99.847	64.417	100.24	64.670	1.0431	.67295	1.041	.59360
400.00	2.4122	3.7390	103.95	67.066	104.36	67.329	1.0826	.69843	1.037	.60748
410.00	2.3848	3.6964	108.11	69.746	108.55	70.019	1.1224	.72411	1.034	.62106
420.00	2.3586	3.6559	112.31	72.456	112.75	72.739	1.1625	.75000	1.031	.63433
430.00	2.3338	3.6174	116.55	75.195	117.01	75.489	1.2029	.77608	1.028	.64726
440.00	2.3101	3.5807	120.84	77.963	121.32	78.268	1.2436	.80235	1.025	.65987
450.00	2.2875	3.5456	125.18	80.759	125.67	81.075	1.2847	.82881	1.022	.67215
460.00	2.2659	3.5122	129.55	83.582	130.06	83.909	1.3259	.85544	1.019	.68409
470.00	2.2453	3.4803	133.97	86.432	134.49	86.769	1.3675	.88224	1.017	.69571
480.00	2.2257	3.4498	138.43	89.307	138.97	89.655	1.4093	.90921	1.014	.70700
490.00	2.2068	3.4206	142.92	92.207	143.48	92.566	1.4513	.93633	1.012	.71797

# CALCIUM

PROCTON ENERGY MEV	ENERGY LOSS NEV/ GM/CM2	PROTON RANGE GM/CM2 CM	PROTON PATH LENGTH GM/CM2 CM	PATH LENGTH STRAGGLING GM/CM2 CM PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.1888	3.3926	147.45	95.132	145.03	95.502
510.00	2.1715	3.3658	152.02	98.080	152.61	98.461
520.00	2.1549	3.3401	157.63	101.05	157.24	101.44
530.00	2.1390	3.3155	161.27	104.04	161.90	104.45
540.00	2.1238	3.2910	165.94	107.06	166.59	107.48
550.00	2.1091	3.2691	170.65	110.10	171.31	110.52
560.00	2.0950	3.2473	175.39	113.16	176.07	113.59
570.00	2.0815	3.2263	180.16	116.23	180.86	116.68
580.00	2.0684	3.2061	184.96	119.33	185.68	119.79
590.00	2.0559	3.1866	189.79	122.45	190.53	122.92
600.00	2.0438	3.1679	194.65	125.58	195.41	126.07
620.00	2.0209	3.1324	204.46	131.91	205.25	132.42
640.00	1.9997	3.0995	214.37	138.30	215.20	138.64
660.00	1.9798	3.0687	224.39	144.77	225.25	145.32
680.00	1.9614	3.0401	234.50	151.29	235.40	151.87
700.00	1.9441	3.0133	244.70	157.87	245.64	158.43
720.00	1.9279	2.9883	255.00	164.51	255.97	165.14
740.00	1.9128	2.9648	265.37	171.21	266.39	171.86
760.00	1.8986	2.9428	275.83	177.96	276.89	179.64
780.00	1.8853	2.9222	286.37	184.75	287.46	185.46
800.00	1.8728	2.9028	296.97	191.59	298.10	192.32
820.00	1.8610	2.8845	307.65	198.48	308.82	199.24
840.00	1.8499	2.8673	318.39	205.41	319.60	206.19
860.00	1.8395	2.8512	329.19	212.38	330.44	213.19
880.00	1.8296	2.8359	340.06	219.39	341.35	220.22
900.00	1.8203	2.8215	350.99	226.44	352.31	227.30
920.00	1.8115	2.8079	361.97	233.53	363.33	234.41
940.00	1.8033	2.7950	373.01	240.65	374.41	241.56
960.00	1.7954	2.7829	384.11	247.81	385.55	248.74
1000.00	1.7810	2.7606	406.56	262.30	408.08	263.28
500.00	1.8728	2.9028	296.97	191.59	298.10	192.32
510.00	1.8610	2.8845	307.65	198.48	308.82	199.24
520.00	1.8499	2.8673	318.39	205.41	319.60	206.19
530.00	1.8395	2.8512	329.19	212.38	330.44	213.19
540.00	1.8296	2.8359	340.06	219.39	341.35	220.22
550.00	1.8203	2.8215	350.99	226.44	352.31	227.30
560.00	1.8115	2.8079	361.97	233.53	363.33	234.41
570.00	1.8033	2.7950	373.01	240.65	374.41	241.56
580.00	1.7954	2.7829	384.11	247.81	385.55	248.74
590.00	1.7810	2.7606	406.56	262.30	408.08	263.28
600.00	1.8728	2.9028	296.97	191.59	298.10	192.32
620.00	1.8610	2.8845	307.65	198.48	308.82	199.24
640.00	1.8499	2.8673	318.39	205.41	319.60	206.19
660.00	1.8395	2.8512	329.19	212.38	330.44	213.19
680.00	1.8296	2.8359	340.06	219.39	341.35	220.22
700.00	1.8203	2.8215	350.99	226.44	352.31	227.30
720.00	1.8115	2.8079	361.97	233.53	363.33	234.41
740.00	1.8033	2.7950	373.01	240.65	374.41	241.56
760.00	1.7954	2.7829	384.11	247.81	385.55	248.74
780.00	1.7810	2.7606	406.56	262.30	408.08	263.28
800.00	1.8728	2.9028	296.97	191.59	298.10	192.32
820.00	1.8610	2.8845	307.65	198.48	308.82	199.24
840.00	1.8499	2.8673	318.39	205.41	319.60	206.19
860.00	1.8395	2.8512	329.19	212.38	330.44	213.19
880.00	1.8296	2.8359	340.06	219.39	341.35	220.22
900.00	1.8203	2.8215	350.99	226.44	352.31	227.30
920.00	1.8115	2.8079	361.97	233.53	363.33	234.41
940.00	1.8033	2.7950	373.01	240.65	374.41	241.56
960.00	1.7954	2.7829	384.11	247.81	385.55	248.74
1000.00	1.7810	2.7606	406.56	262.30	408.08	263.28

THE ELECTRON DENSITY OF CALCIUM IS 3.006E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.141 BEV, AND THE MINIMUM ENERGY LOSS IS 1.6644 MEV/GM/CM2

## CARBON

ATOMIC NUMBER 6  
ELEMENT C  
ATOMS/MOLECULE 1  
ADJUSTED IONIZATION POTENTIAL 75.10  
ATOMIC WEIGHT 12.011

DENSITY \* 2.2200 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS GM/CH2	MEV/CM	PROTON RANGE MG/CH2	MM	PROTON PATH LENGTH MG/CH2	MM	MG/CH2	PATH LENGTH STRAGGLING MM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	622.92	1826.9	.15995	.00072	.16111	.00073	.00530	.00002	3.291	.7200	0.
.15	720.41	1599.3	.22478	.00101	.22601	.00102	.00635	.00003	2.810	.5429	0.
.20	635.71	1411.3	.29848	.00134	.29985	.00135	.00771	.00003	2.571	.4568	0.
.30	509.25	1130.5	.47443	.00214	.47620	.00215	.01117	.00005	2.346	.3711	0.
.40	424.85	943.17	.68965	.00311	.69192	.00312	.01551	.00007	2.242	.3277	0.
.50	367.65	816.18	.94268	.00425	.94553	.00426	.02057	.00009	2.175	.3014	0.
.60	326.61	725.07	1.2310	.00555	1.2345	.00556	.02618	.00012	2.121	.2836	0.
.70	294.48	653.75	1.5536	.00699	1.5569	.00701	.03226	.00015	2.072	.2707	0.
.80	267.87	594.67	1.9079	.00859	1.9129	.00862	.03885	.00018	2.031	.2607	0.
.90	249.38	553.63	2.2937	.01033	2.2995	.01036	.04583	.00021	1.994	.2527	0.
1.00	230.88	512.55	2.7097	.01221	2.7163	.01224	.05319	.00024	1.958	.2460	0.
1.20	203.65	452.11	3.6319	.01636	3.6405	.01640	.06917	.00031	1.900	.2356	0.
1.40	182.92	406.07	4.6679	.02103	4.6785	.02107	.08656	.00039	1.850	.2276	.00001
1.60	166.46	369.59	5.8136	.02619	5.8265	.02625	.10531	.00047	1.807	.2213	.00001
1.80	153.08	339.03	7.0656	.03183	7.0809	.03190	.12537	.00056	1.771	.2160	.00002
2.00	141.89	315.00	8.4211	.03793	8.4389	.03801	.14671	.00066	1.739	.2115	.00003
2.20	132.39	293.91	9.8782	.04450	9.8987	.04459	.16932	.00076	1.710	.2076	.00005
2.40	124.21	275.75	11.436	.05151	11.459	.05162	.19316	.00087	1.686	.2042	.00007
2.60	117.08	259.92	13.093	.05898	13.119	.05909	.21821	.00098	1.663	.2012	.00010
2.80	110.80	245.98	14.846	.06687	14.876	.06701	.24447	.00110	1.643	.1985	.00012
3.00	105.22	233.60	16.696	.07521	16.728	.07535	.27191	.00122	1.625	.1961	.00015
3.20	100.24	222.52	18.640	.08397	18.676	.08413	.30052	.00135	1.609	.1938	.00019
3.40	95.742	212.55	20.679	.09315	20.719	.09333	.33029	.00149	1.594	.1918	.00022
3.60	91.672	203.51	22.811	.10275	22.855	.10295	.36119	.00163	1.580	.1900	.00027
3.80	87.967	195.29	25.035	.11277	25.082	.11298	.39322	.00177	1.568	.1882	.00031
4.00	84.577	187.76	27.350	.12320	27.401	.12343	.42637	.00192	1.556	.1866	.00035
4.20	81.302	180.49	29.760	.13405	29.815	.13430	.46078	.00208	1.545	.1851	.00040
4.40	78.453	174.17	32.263	.14533	32.322	.14560	.49630	.00224	1.535	.1837	.00045
4.60	75.815	168.31	34.847	.15697	34.911	.15726	.53288	.00240	1.526	.1824	.00050
4.80	73.364	162.87	37.529	.16905	37.597	.16936	.57051	.00257	1.517	.1812	.00056

## CARBON

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PATH LENGTH GM/CM2		PATH LENGTH STRAGGLING GM/CM2		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CH	GM/CM2	PERCENT		
5.00	71.081	0.4029	0.1815	0.4037	0.1818	0.0061	1.509	.1801	.00061
5.50	66.001	0.4759	0.2144	0.4767	0.2147	0.0071	1.490	.1775	.00077
6.00	61.656	0.5542	0.2496	0.5552	0.2501	0.0082	1.473	.1752	.00202
6.50	57.894	0.6378	0.2873	0.6389	0.2878	0.0093	1.459	.1731	.00573
7.00	54.603	0.7266	0.3273	0.7279	0.3279	0.0105	1.445	.1714	.00864
7.50	51.697	0.8206	0.3697	0.8220	0.3703	0.0118	1.433	.1697	.01153
8.00	49.111	0.9197	0.4143	0.9213	0.4150	0.0131	1.422	.1682	.01442
8.50	46.794	1.0239	0.4612	1.0256	0.4620	0.0145	1.412	.1669	.01731
9.00	44.705	1.1331	0.5104	1.1350	0.5112	0.0159	1.403	.1657	.02018
9.50	42.811	1.2472	0.5618	1.2493	0.5627	0.0174	1.394	.1645	.02306
10.00	41.085	1.3663	0.6155	1.3685	0.6165	0.0190	1.386	.1635	.02593
11.00	38.054	1.6191	0.7293	1.6217	0.7305	0.0222	1.372	.1616	.03167
12.00	35.476	1.8910	0.8518	1.8940	0.8532	0.0257	1.359	.1599	.03740
13.00	33.255	2.1818	0.9828	2.1853	0.9844	0.0295	1.348	.1585	.04313
14.00	31.320	2.4914	1.1223	2.4954	1.1240	0.0334	1.338	.1572	.04886
15.00	29.617	2.8196	1.2700	2.8238	1.2720	0.0375	1.329	.1560	.05459
16.00	28.107	3.1656	1.4260	3.1705	1.4282	0.0419	1.320	.1549	.06031
17.00	26.758	3.5299	1.5900	3.5353	1.5925	0.0464	1.312	.1539	.06604
18.00	25.544	3.9120	1.7621	3.9180	1.7648	0.0511	1.305	.1530	.07176
19.00	24.447	4.3116	1.9422	4.3182	1.9451	0.0561	1.298	.1522	.07749
20.00	23.449	4.7288	2.1301	4.7360	2.1333	0.0612	1.292	.1515	.08321
22.00	21.702	5.6149	2.5292	5.6233	2.5330	0.0720	1.281	.1501	.09465
24.00	20.221	6.5898	2.9590	6.5787	2.9634	0.0836	1.270	.1489	.10609
26.00	18.949	7.5898	3.4168	7.6011	3.4239	0.0959	1.261	.1479	.11293
28.00	17.844	8.6765	3.9083	8.6893	3.9141	0.1089	1.253	.1469	.11506
30.00	16.874	9.8280	4.4270	9.8424	4.4335	0.1225	1.245	.1461	.11727
32.00	16.016	1.1043	4.9745	1.1059	4.9817	0.1369	1.238	.1453	.11955
34.00	15.251	1.2322	5.5503	1.2340	5.5583	0.1519	1.231	.1446	.12190
36.00	14.564	1.3662	6.1542	1.3682	6.1630	0.1676	1.225	.1440	.12431
38.00	13.944	1.5064	6.7857	1.5086	6.7954	0.1840	1.219	.1434	.12678
40.00	13.381	1.6527	7.4445	1.6550	7.4551	0.2009	1.214	.1428	.12929
45.00	12.177	2.0444	9.2088	2.0473	9.2219	0.2460	1.202	.1416	.13575
50.00	11.197	2.4724	1.1137	2.4759	1.1153	0.2948	1.191	.1406	.14239
55.00	10.383	2.9359	1.3225	2.9400	1.3243	0.3472	1.181	.1397	.14925
60.00	9.6960	3.4340	1.5468	3.4387	1.5490	0.4030	1.172	.1390	.15640
65.00	9.1076	3.9656	1.7863	3.9711	1.7888	0.4622	1.164	.1383	.16379
70.00	8.5979	4.5302	2.0406	4.5365	2.0434	0.5245	1.156	.1377	.17138
75.00	8.1519	5.1269	2.3094	5.1340	2.3126	0.5900	1.149	.1371	.17915
80.00	7.7582	5.7551	2.5924	5.7629	2.5959	0.6586	1.143	.1366	.18704
90.00	7.0945	7.1029	3.1995	7.1126	3.2039	0.8043	1.131	.1357	.20310

## CARBON

PRCTON ENERGY MEV	ENERGY LOSS MEV/ GM/CH2	PROTON RANGE GM/CH2	CH	PROTON PATH LENGTH GM/CH2	CH	PATH LENGTH STRAGGLING GM/CH2	CH	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	6.5563	14.555	8.5688	3.8650	0.9611	.04329	1.120	.1350	.21932	
110.00	6.1107	13.566	4.9712	4.5773	.11284	.05083	1.110	.1344	.23580	
120.00	5.7356	12.733	11.836	5.3316	.11852	.05880	1.101	.1338	.25270	
130.00	5.4155	12.022	13.629	6.1474	.13647	.06720	1.093	.1333	.26990	
140.00	5.1389	11.408	15.523	6.9924	.15544	.07601	1.086	.1329	.28728	
150.00	4.8976	10.873	17.515	7.9000	.17538	.08519	1.078	.1324	.30474	
160.00	4.6852	10.401	19.600	8.8407	.19626	.09473	1.072	.1321	.32230	
170.00	4.4967	9.9826	21.777	9.8224	.21806	.10462	1.065	.1317	.33996	
180.00	4.3285	9.6092	24.041	10.844	.24073	.11484	1.059	.1314	.35765	
190.00	4.1773	9.2736	26.391	11.888	.26425	.12537	1.053	.1311	.37530	
200.00	4.0407	8.9704	28.822	13.000	.30238	.13621	1.048	.1308	.39287	
210.00	3.9168	8.6953	31.333	14.132	.32707	.14733	1.042	.1306	.41033	
220.00	3.8038	8.4445	33.921	15.300	.35236	.15872	1.037	.1303	.42765	
230.00	3.7004	8.2149	36.584	16.501	.37824	.17038	1.033	.1301	.44479	
240.00	3.6054	8.0041	39.318	17.734	.40468	.18229	1.028	.1299	.46172	
250.00	3.5179	7.8098	42.123	18.999	.43166	.19444	1.023	.1297	.47840	
260.00	3.4370	7.6302	44.995	20.295	.45915	.20682	1.019	.1295	.49463	
270.00	3.3620	7.4636	47.934	21.620	.48713	.21943	1.015	.1293	.51100	
280.00	3.2923	7.3089	50.936	22.974	.51559	.23225	1.011	.1291	.52688	
290.00	3.2274	7.1647	54.000	24.356	.54450	.24527	1.007	.1289	.54246	
300.00	3.1667	7.0301	57.125	25.765	.57385	.25849	1.003	.1287	.55772	
310.00	3.1100	6.9042	60.308	27.201	.60361	.27190	.9996	.1286	.57270	
320.00	3.0568	6.7861	63.547	28.662	.63378	.28549	.9961	.1284	.58747	
330.00	3.0068	6.6752	66.842	30.148	.66434	.29925	.9926	.1282	.60200	
340.00	2.9598	6.5708	70.120	31.658	.69527	.31319	.9893	.1281	.61628	
350.00	2.9155	6.4725	73.590	33.191	.72657	.32728	.9861	.1279	.63029	
360.00	2.8737	6.3797	77.041	34.747	.75821	.34153	.9829	.1278	.64410	
370.00	2.8342	6.2920	80.540	36.326	.79018	.35594	.9798	.1276	.65776	
380.00	2.7968	6.2089	84.088	37.926	.82248	.37049	.9769	.1275	.67125	
390.00	2.7614	6.1303	87.682	39.547	.85509	.38517	.9740	.1273	.68455	
400.00	2.7278	6.0557	91.321	41.188	.88799	.40000	.9711	.1272	.69763	
410.00	2.6958	5.9848	95.005	42.849	.92119	.41495	.9684	.1270	.71041	
420.00	2.6655	5.9174	98.731	44.530	.95467	.43003	.9657	.1269	.72277	
430.00	2.6366	5.8532	102.50	46.229	.98842	.44523	.9631	.1267	.73474	
440.00	2.6090	5.7921	106.31	47.946	1.0224	.46055	.9606	.1266	.74630	
450.00	2.5828	5.7336	110.15	49.682	1.0567	.47598	.9581	.1265	.75746	
460.00	2.5577	5.6781	114.04	51.435	1.0912	.49153	.9556	.1263	.76823	
470.00	2.5338	5.6249	118.11	53.204	1.1259	.50718	.9533	.1262	.77862	
480.00	2.5109	5.5741	122.08	54.990	1.1609	.52293	.9510	.1261	.78862	
490.00	2.4889	5.5234	126.08	56.792	1.1961	.53878	.9487	.1259	.79826	

# CARBON

PROTON ENERGY MEV	ENERGY LOSS MEV/CH	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PATH LENGTH STRAGGLING GM/CH2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.4680	5.4789	130.11	58.609	1.2315	.80752
510.00	2.4478	5.4342	134.18	60.442	1.2671	.81643
520.00	2.4286	5.3914	138.28	62.290	1.3029	.82499
530.00	2.4101	5.3503	142.24	64.071	1.3389	.83321
540.00	2.3923	5.3109	146.40	65.945	1.3751	.84110
550.00	2.3752	5.2730	150.59	67.832	1.4115	.84866
560.00	2.3588	5.2365	154.81	69.733	1.4481	.85591
570.00	2.3430	5.2015	159.06	71.737	1.4848	.86286
580.00	2.3278	5.1678	163.33	73.665	1.5217	.86951
590.00	2.3132	5.1353	167.64	75.512	1.5588	.87587
600.00	2.2991	5.1040	171.97	77.463	1.5960	.88196
620.00	2.2724	5.0448	180.71	81.502	1.6709	.89335
640.00	2.2476	4.9897	189.55	85.488	1.7464	.90373
660.00	2.2245	4.9383	198.48	89.407	1.8224	.91320
680.00	2.2028	4.8903	207.51	93.472	1.8990	.92180
700.00	2.1826	4.8455	216.62	97.576	1.9763	.92962
720.00	2.1637	4.8035	225.81	101.72	2.0535	.93671
740.00	2.1460	4.7641	235.02	106.02	2.1315	.94313
760.00	2.1293	4.7271	244.43	110.10	2.2099	.94894
780.00	2.1137	4.6924	253.85	114.34	2.2881	.95418
800.00	2.0990	4.6597	263.33	118.62	2.3679	.95892
820.00	2.0851	4.6289	272.88	122.92	2.4474	.96319
840.00	2.0720	4.5999	282.49	127.25	2.5274	.96703
860.00	2.0597	4.5726	292.17	131.61	2.6076	.97050
880.00	2.0481	4.5467	301.89	135.99	2.6882	.97361
900.00	2.0371	4.5223	311.68	140.40	2.7691	.97640
920.00	2.0267	4.4992	321.52	144.83	2.8503	.97891
940.00	2.0168	4.4774	331.41	149.28	2.9317	.98116
960.00	2.0075	4.4567	341.36	153.76	3.0135	.98318
1000.00	1.9904	4.4186	361.47	162.82	3.1778	.98662

THE ELECTRON DENSITY OF CARBON IS 3.010E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.301 BEV, AND THE MINIMUM ENERGY LOSS IS 1.8403 MEV/GM/CM2

# CESIUM

ELEMENT NUMBER 55  
CS

ATOMS/ MOLECULE 1

ATOMIC WEIGHT 132.90

ADJUSTED IONIZATION POTENTIAL 545.2

DENSITY = 1.9000 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS GM/CM2	MEV/CM	PROTON RANGE MM	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH MM	PATH LENGTH STRAGGLING GM/CM2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	224.24	426.05	.90094	.00474	.93846	.04544	.00024	3.998	0.
.15	203.18	386.04	1.1333	.00596	1.1726	.05017	.00026	3.350	0.
.20	187.39	356.04	1.3855	.00729	1.4288	.05581	.00029	3.030	0.
.30	160.72	305.37	1.9507	.01027	2.0054	.06923	.00036	2.728	0.
.40	140.08	266.15	2.6044	.01371	2.6734	.08555	.00045	2.583	0.
.50	125.29	238.05	3.3437	.01760	3.4292	.10485	.00055	2.493	0.
.60	113.13	214.94	4.1659	.02193	4.2696	.12810	.00067	2.429	0.
.70	104.46	198.48	5.0660	.02666	5.1894	.15413	.00081	2.379	0.
.80	96.477	183.31	6.0408	.03179	6.1854	.18229	.00096	2.337	0.
.90	88.555	168.25	7.0994	.03737	7.2666	.21318	.00112	2.301	0.
1.00	80.630	153.20	8.2581	.04346	8.4499	.24787	.00130	2.269	0.
1.20	73.621	139.88	10.803	.05866	11.048	.32193	.00169	2.219	0.
1.40	68.043	129.28	13.575	.07145	13.877	.39685	.00209	2.179	0.
1.60	63.443	120.54	16.563	.08717	16.926	.47297	.00249	2.144	0.
1.80	59.503	113.06	19.759	.10400	20.186	.55095	.00290	2.112	0.
2.00	56.105	106.60	23.154	.12186	23.647	.63110	.00332	2.082	0.
2.20	53.146	100.98	26.747	.14078	27.308	.71353	.00376	2.054	0.
2.40	50.540	96.025	30.539	.16073	31.171	.79827	.00420	2.028	0.
2.60	48.224	91.626	34.520	.18168	35.226	.88574	.00466	2.004	0.
2.80	46.142	87.670	38.685	.20360	39.467	.97712	.00514	1.981	0.
3.00	44.321	84.210	43.029	.22647	43.889	1.0720	.00564	1.960	0.
3.20	42.666	81.065	47.548	.25025	48.489	1.1700	.00616	1.939	0.
3.40	41.154	78.192	52.239	.27494	53.262	1.2708	.00669	1.920	0.
3.60	39.769	75.562	57.102	.30054	58.209	1.3742	.00723	1.902	0.
3.80	38.489	73.129	62.129	.32699	63.322	1.4803	.00779	1.884	0.
4.00	37.314	70.897	67.318	.35431	68.600	1.5887	.00836	1.868	0.
4.20	36.216	68.811	72.671	.38248	74.042	1.6994	.00894	1.852	0.
4.40	35.200	66.881	78.182	.41148	79.645	1.8124	.00954	1.837	0.
4.60	34.250	65.075	83.844	.44129	85.401	1.9275	.01014	1.822	0.
4.80	33.359	63.382	89.671	.47195	91.323	2.0448	.01076	1.809	0.

CESIUM

PROTON ENERGY MEV	ENERGY LOSS HEV/CH2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CH2	PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
				GM/CH2	PERCENT		
5.00	32.522	61.791	.09739	.05126	.00114	2.222	0.
5.50	30.629	58.196	.11325	.05960	.00216	2.222	0.
6.00	28.978	55.058	.13004	.06844	.00247	2.182	0.
6.50	27.522	52.292	.14775	.07776	.00279	2.146	0.
7.00	26.227	49.831	.16637	.08756	.00312	2.113	0.
7.50	25.066	47.626	.18587	.09783	.00346	2.083	.00001
8.00	24.020	45.636	.20625	.10856	.00382	2.055	.00001
8.50	23.071	43.836	.22750	.11974	.00419	2.029	.00002
9.00	22.206	42.191	.24960	.13137	.00456	2.005	.00003
9.50	21.410	40.680	.27253	.14344	.00495	1.983	.00004
					.00535	1.962	.00006
10.00	20.679	39.291	.29629	.15594	.00576	1.943	.00008
11.00	19.381	36.824	.34628	.18225	.00660	1.907	.00014
12.00	18.259	34.693	.39340	.21026	.00749	1.875	.00022
13.00	17.288	32.848	.45581	.23990	.00843	1.847	.00032
14.00	16.429	31.215	.51516	.27113	.00938	1.821	.00045
15.00	15.689	29.809	.57744	.30392	.01037	1.796	.00060
16.00	14.993	28.406	.64264	.33823	.01140	1.774	.00077
17.00	14.371	27.305	.71075	.37408	.01247	1.754	.00098
18.00	13.806	26.231	.78178	.41147	.01357	1.736	.00120
19.00	13.288	25.247	.85566	.45035	.01471	1.719	.00145
20.00	12.814	24.347	.93227	.49067	.01589	1.704	.00172
22.00	11.974	22.750	1.0939	.57572	.01835	1.678	.00383
24.00	11.249	21.374	1.2663	.66647	.02095	1.654	.00772
26.00	10.619	20.175	1.4494	.76283	.02369	1.634	.01040
28.00	10.064	19.121	1.6429	.86488	.02655	1.616	.01183
30.00	9.5720	18.187	1.8468	.97199	.02954	1.600	.01332
32.00	9.1329	17.352	2.0608	1.0846	.03255	1.584	.01486
34.00	8.7381	16.602	2.2847	1.2025	.03588	1.571	.01646
36.00	8.3811	15.924	2.5184	1.3255	.03923	1.558	.01811
38.00	8.0566	15.308	2.7619	1.4536	.04269	1.546	.01980
40.00	7.7591	14.742	3.0149	1.5868	.04627	1.535	.02155
45.00	7.1172	13.523	3.6886	1.9414	.05568	1.510	.02610
50.00	6.5932	12.527	4.4191	2.3259	.06574	1.488	.03090
55.00	6.1530	11.691	5.2048	2.7394	.07642	1.468	.03594
60.00	5.7774	10.977	6.0440	3.1811	.08768	1.451	.04123
65.00	5.4533	10.361	6.9353	3.6502	.09951	1.435	.04676
70.00	5.1704	9.8237	7.8772	4.1459	.11189	1.420	.05250
75.00	4.9212	9.3504	8.8689	4.6679	.12480	1.407	.05843
80.00	4.7001	8.9302	9.9089	5.2152	.13822	1.395	.06455
90.00	4.3245	8.2166	12.130	6.3841	.16653	1.373	.07724



CESIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GH/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	CH PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	4.9174	14.365	14.531	19670	1.354	1.142	.09045
110.00	3.7614	16.912	17.106	.22862	1.337	1.133	.10416
120.00	3.5445	19.623	19.846	.26218	1.321	1.126	.11840
130.00	3.3585	22.492	22.746	.29730	1.307	1.119	.13308
140.00	3.1971	25.512	25.799	.33389	1.294	1.114	.14812
150.00	3.0557	28.678	29.000	.37187	1.282	1.109	.16346
160.00	2.9329	31.983	32.340	.41114	1.271	1.105	.17907
170.00	2.8215	35.426	35.820	.45162	1.261	1.101	.19493
180.00	2.7217	38.994	39.427	.49330	1.251	1.098	.21131
190.00	2.6319	42.694	43.166	.53513	1.242	1.095	.22724
200.00	2.5506	46.515	47.028	.58004	1.233	1.092	.24359
210.00	2.4767	50.448	51.004	.62499	1.225	1.089	.25999
220.00	2.4092	54.501	55.100	.67092	1.218	1.087	.27636
230.00	2.3473	58.663	59.307	.71779	1.210	1.085	.29268
240.00	2.2904	62.933	63.622	.76556	1.203	1.083	.30892
250.00	2.2372	67.301	68.036	.81419	1.197	1.081	.32504
260.00	2.1886	71.775	72.558	.86367	1.190	1.079	.34110
270.00	2.1435	76.344	77.176	.91394	1.184	1.078	.35716
280.00	2.1015	81.004	81.885	.96495	1.178	1.076	.37320
290.00	2.0624	85.757	86.689	1.0167	1.173	1.075	.38918
300.00	2.0258	90.604	91.587	1.0691	1.167	1.073	.40508
310.00	1.9916	95.531	96.566	1.1222	1.162	1.072	.42084
320.00	1.9595	100.54	101.63	1.1759	1.157	1.071	.43641
330.00	1.9293	105.62	106.77	1.2302	1.152	1.070	.45178
340.00	1.9009	110.79	111.99	1.2851	1.147	1.069	.46692
350.00	1.8741	116.03	117.29	1.3405	1.143	1.068	.48183
360.00	1.8489	121.35	122.66	1.3965	1.139	1.067	.49652
370.00	1.8250	126.74	128.10	1.4530	1.134	1.066	.51102
380.00	1.8023	132.20	133.62	1.5099	1.130	1.065	.52531
390.00	1.7809	137.72	139.21	1.5674	1.126	1.064	.53938
400.00	1.7606	143.31	144.85	1.6253	1.122	1.063	.55322
410.00	1.7412	148.97	150.57	1.6836	1.118	1.063	.56683
420.00	1.7229	154.68	156.34	1.7424	1.114	1.062	.58020
430.00	1.7054	160.45	162.17	1.8016	1.111	1.061	.59331
440.00	1.6887	166.28	168.07	1.8611	1.107	1.060	.60616
450.00	1.6728	172.17	174.02	1.9211	1.104	1.060	.61875
460.00	1.6576	178.11	180.02	1.9813	1.101	1.059	.63106
470.00	1.6433	184.11	186.08	2.0420	1.097	1.058	.64314
480.00	1.6293	190.16	192.19	2.1030	1.094	1.058	.65493
490.00	1.6160	196.26	198.36	2.1643	1.091	1.057	.66645

# CESIUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/CH2	MEV/CM	GM/CH2	CM	GM/CH2	CM	GM/CH2	CM		
500.00	1.6033	3.0464	202.41	106.53	204.57	107.57	2.2259	1.1715	1.088	.67769
510.00	1.5912	3.0233	208.60	109.79	210.83	110.96	2.2878	1.2041	1.085	.68866
520.00	1.5795	3.0011	214.84	113.08	217.14	114.28	2.3501	1.2369	1.082	.69936
530.00	1.5684	2.9799	221.13	116.39	223.49	117.63	2.4126	1.2698	1.079	.70978
540.00	1.5576	2.9595	227.46	119.72	229.89	120.99	2.4753	1.3028	1.077	.71993
550.00	1.5473	2.9399	233.84	123.07	236.33	124.38	2.5384	1.3360	1.074	.72982
560.00	1.5374	2.9211	240.26	126.45	242.81	127.80	2.6016	1.3693	1.071	.73943
570.00	1.5279	2.9031	246.71	129.85	249.34	131.23	2.6652	1.4027	1.069	.74878
580.00	1.5188	2.8857	253.21	133.27	255.90	134.68	2.7290	1.4363	1.066	.75787
590.00	1.5100	2.8699	259.75	136.71	262.50	138.16	2.7930	1.4700	1.064	.76670
600.00	1.5015	2.8528	266.32	140.17	269.15	141.66	2.8572	1.5038	1.062	.77527
620.00	1.4855	2.8224	279.57	147.14	282.54	148.70	2.9863	1.5717	1.057	.79165
640.00	1.4706	2.7941	292.97	154.19	296.07	155.83	3.1161	1.6401	1.053	.80705
660.00	1.4567	2.7677	306.49	161.31	309.73	163.02	3.2468	1.7088	1.048	.82151
680.00	1.4438	2.7431	320.15	168.50	323.53	170.28	3.3782	1.7780	1.044	.83505
700.00	1.4317	2.7202	333.92	175.75	337.44	177.60	3.5102	1.8475	1.040	.84772
720.00	1.4204	2.6988	347.80	183.05	351.47	184.98	3.6428	1.9173	1.036	.85956
740.00	1.4099	2.6788	361.79	190.42	365.60	192.42	3.7761	1.9874	1.033	.87060
760.00	1.4000	2.6600	375.88	197.83	379.84	199.91	3.9099	2.0578	1.029	.88088
780.00	1.3907	2.6424	390.07	205.30	394.17	207.46	4.0442	2.1285	1.026	.89044
800.00	1.3820	2.6259	404.35	212.82	408.59	215.05	4.1791	2.1995	1.023	.89932
820.00	1.3739	2.6103	418.72	220.38	423.11	222.69	4.3144	2.2707	1.020	.90756
840.00	1.3662	2.5958	433.17	227.98	437.71	230.37	4.4501	2.3422	1.017	.91520
860.00	1.3590	2.5821	447.74	235.65	452.42	238.12	4.5863	2.4138	1.014	.92227
880.00	1.3522	2.5691	462.44	243.39	467.27	245.93	4.7229	2.4857	1.011	.92881
900.00	1.3458	2.5570	477.20	251.16	482.19	253.78	4.8598	2.5578	1.008	.93484
920.00	1.3398	2.5455	491.97	258.93	497.10	261.63	4.9972	2.6301	1.005	.94041
940.00	1.3341	2.5347	506.73	266.70	512.01	269.48	5.1348	2.7025	1.003	.94555
960.00	1.3287	2.5245	521.65	274.55	527.07	277.41	5.2728	2.7752	1.000	.95027
1000.00	1.3189	2.5059	551.85	290.45	557.56	293.45	5.5498	2.9209	.9954	.95856

THE ELECTRON DENSITY OF CESIUM IS 2.493E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.985 BEV, AND THE MINIMUM ENERGY LOSS IS 1.2450 MEV/GH/CM2

# CHLORINE

ELEMENT CL  
 ATOMIC NUMBER 17  
 ATOMS/MOLECULE 2  
 ATOMIC WEIGHT 35.453  
 ADJUSTED IONIZATION POTENTIAL 170.0

DENSITY = 3.1633 MG/CM3

FRCION ENERGY MEV	ENERGY LOSS KEV/CM	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		MG/CM2	METER	MG/CM2	METER	MG/CM2	METER PERCENT		
.10	473.85	33021	.00104	.33562	.00106	.01349	.00004	1.612	0.
.15	415.91	44243	.00140	.44817	.00142	.01572	.00005	1.281	0.
.20	367.40	56954	.00180	.57600	.00182	.01865	.00006	1.123	0.
.30	296.42	87199	.00276	.88053	.00278	.02622	.00008	.9699	0.
.40	255.50	12342	.00390	1.2453	.00394	.03534	.00011	.8553	0.
.50	226.24	16476	.00521	1.6617	.00525	.04532	.00014	.8491	0.
.60	205.95	21288	.00667	2.1262	.00672	.05603	.00018	.8158	0.
.70	189.61	26113	.00825	2.6321	.00832	.06711	.00021	.7899	0.
.80	176.19	31549	.00997	3.1793	.01005	.07868	.00025	.7681	0.
.90	172.37	37245	.01177	3.7526	.01186	.08999	.00028	.7497	0.
1.00	168.53	43080	.01362	4.3398	.01372	.10052	.00032	.7332	0.
1.20	150.54	55583	.01757	5.5977	.01770	.12231	.00039	.7034	0.
1.40	136.50	69477	.02196	6.9951	.02211	.14658	.00046	.6774	0.
1.60	125.15	84713	.02678	8.5271	.02696	.17364	.00055	.6547	0.
1.80	115.74	10125	.03201	10.190	.03221	.20320	.00064	.6350	0.
2.00	107.77	11909	.03765	11.983	.03788	.23501	.00074	.6178	0.
2.20	100.94	13817	.04368	13.901	.04395	.26891	.00085	.6027	.00001
2.40	95.046	15850	.05011	15.944	.05040	.30475	.00096	.5894	.00001
2.60	89.924	18004	.05691	18.109	.05725	.34239	.00108	.5775	.00001
2.80	85.288	20277	.06410	20.393	.06447	.38177	.00121	.5668	.00001
3.00	81.252	22670	.07166	22.797	.07207	.42292	.00134	.5572	.00002
3.20	77.647	25176	.07959	25.315	.08003	.46558	.00147	.5486	.00002
3.40	74.382	27796	.08787	27.947	.08835	.50976	.00161	.5407	.00003
3.60	71.420	30529	.09651	30.693	.09703	.55541	.00176	.5335	.00004
3.80	68.693	33372	.10550	33.549	.10606	.60254	.00190	.5268	.00005
4.00	66.187	36385	.11483	36.515	.11543	.65113	.00206	.5207	.00005
4.20	63.880	39387	.12451	39.591	.12516	.70116	.00222	.5151	.00007
4.40	61.748	42559	.13454	42.777	.13523	.75261	.00238	.5098	.00008
4.60	59.773	45838	.14491	46.071	.14564	.80545	.00255	.5049	.00009
4.80	57.935	49223	.15560	49.470	.15639	.85966	.00272	.5003	.00010

# CHLORINE

PRCTCN ENERGY MEV	ENERGY LOSS MEV/ GM/CH2	PROTON RANGE		PATH LENGTH GM/CH2		PATH LENGTH STRAGGLING GM/CH2		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CH2	METER	GM/CH2	METER	GM/CH2	METER PERCENT		
5.00	56.220	0.5271	1.6663	0.5297	1.6746	0.0092	0.0289	1.728	.00012
5.50	52.393	0.6189	1.9565	0.6219	1.9661	0.0106	0.0335	1.704	.00016
6.00	49.105	0.7171	2.2670	0.7206	2.2779	0.0121	0.0383	1.683	.00022
6.50	46.246	0.8217	2.5975	0.8255	2.6097	0.0137	0.0434	1.664	.00028
7.00	43.736	0.9324	2.9476	0.9368	2.9614	0.0154	0.0488	1.646	.00035
7.50	41.512	1.0493	3.3172	1.0542	3.3324	0.0172	0.0543	1.630	.00043
8.00	39.528	1.1723	3.7059	1.1776	3.7228	0.0200	0.0601	1.616	.00076
8.50	37.745	1.3013	4.1136	1.3071	4.1321	0.0209	0.0662	1.602	.00122
9.00	36.133	1.4361	4.5400	1.4425	4.5602	0.0229	0.0725	1.589	.00168
9.50	34.669	1.5769	4.9849	1.5839	5.0069	0.0250	0.0790	1.577	.00215
10.00	33.331	1.7234	5.4481	1.7310	5.4720	0.0271	0.0857	1.566	.00263
11.00	30.976	2.0337	6.4288	2.0424	6.4566	0.0316	0.0998	1.546	.00437
12.00	28.964	2.3664	7.4808	2.3765	7.5127	0.0363	0.1147	1.527	.00729
13.00	27.239	2.7213	8.6036	2.7327	8.6388	0.0413	0.1305	1.511	.01022
14.00	25.716	3.0978	9.7930	3.1108	9.8338	0.0465	0.1471	1.496	.01318
15.00	24.373	3.4959	1.1051	3.5103	1.1097	0.0520	0.1645	1.482	.01615
16.00	23.177	3.9151	1.2377	3.9312	1.2427	0.0578	0.1827	1.470	.01914
17.00	22.106	4.3554	1.3768	4.3731	1.3824	0.0638	0.2016	1.458	.02215
18.00	21.141	4.8165	1.5226	4.8359	1.5287	0.0700	0.2213	1.448	.02518
19.00	20.265	5.2979	1.6748	5.3191	1.6815	0.0765	0.2418	1.438	.02823
20.00	19.467	5.7996	1.8334	5.8227	1.8407	0.0832	0.2630	1.429	.03130
22.00	18.066	6.8630	2.1695	6.8900	2.1781	0.0973	0.3076	1.412	.03749
24.00	16.873	8.0051	2.5306	8.0363	2.5405	0.1123	0.3550	1.397	.04374
26.00	15.846	9.2245	2.9161	9.2602	2.9273	0.1282	0.4051	1.384	.04775
28.00	14.950	1.0520	3.3256	1.0560	3.3383	0.1449	0.4580	1.372	.04942
30.00	14.162	1.1890	3.7588	1.1936	3.7731	0.1624	0.5135	1.361	.05115
32.00	13.462	1.3334	4.2152	1.3384	4.2311	0.1808	0.5716	1.351	.05296
34.00	12.838	1.4850	4.6945	1.4906	4.7122	0.2000	0.6322	1.342	.05483
36.00	12.273	1.6439	5.1966	1.6500	5.2161	0.2200	0.6954	1.333	.05676
38.00	11.765	1.8058	5.7211	1.8165	5.7424	0.2407	0.7609	1.325	.05874
40.00	11.304	1.9826	6.2574	1.9900	6.2907	0.2622	0.8289	1.318	.06078
45.00	10.313	2.4447	7.7282	2.4537	7.7566	0.3192	1.0089	1.301	.06607
50.00	9.5032	2.9485	9.3210	2.9593	9.3549	0.3806	1.2030	1.286	.07162
55.00	8.8288	3.4930	11.042	3.5056	11.082	0.4462	1.4107	1.273	.07742
60.00	8.2579	4.0769	12.888	4.0916	12.934	0.5160	1.6313	1.261	.08349
65.00	7.7680	4.6995	14.856	4.7162	14.909	0.5898	1.8646	1.251	.08981
70.00	7.3427	5.3595	16.943	5.3786	17.003	0.6674	2.1099	1.241	.09633
75.00	6.9699	6.0564	19.146	6.0778	19.213	0.7488	2.3670	1.232	.10305
80.00	6.6403	6.7891	21.462	6.8131	21.536	0.8337	2.6355	1.224	.10992
90.00	6.0835	8.3592	26.425	8.3885	26.518	1.0139	3.2651	1.209	.12405

# CHLORINE

PROCTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	5.6308	10.064	10.099	.12072	.3469	.13854
110.00	5.2554	11.897	11.939	.14129	.3453	.15343
120.00	4.9386	13.855	13.903	.16303	.3438	.16876
130.00	4.6681	15.932	15.987	.18587	.3425	.18450
140.00	4.4340	18.124	18.186	.20976	.3414	.20050
150.00	4.2296	20.426	20.496	.23465	.3404	.21668
160.00	4.0494	22.835	22.913	.26049	.3396	.23305
170.00	3.8894	25.347	25.434	.28723	.3388	.24964
180.00	3.7464	27.959	28.054	.31483	.3380	.26638
190.00	3.6179	30.667	30.771	.34325	.3374	.28322
200.00	3.5017	33.468	33.581	.37245	.3368	.30009
210.00	3.3962	36.359	36.481	.40240	.3362	.31700
220.00	3.3000	39.337	39.469	.43305	.3357	.33393
230.00	3.2118	42.399	42.541	.46439	.3352	.35083
240.00	3.1309	45.542	45.695	.49639	.3347	.36768
250.00	3.0562	48.765	48.928	.52963	.3343	.38443
260.00	2.9872	52.064	52.238	.56222	.3339	.40109
270.00	2.9232	55.437	55.623	.59601	.3335	.41764
280.00	2.8637	58.883	59.080	.63034	.3331	.43407
290.00	2.8082	62.398	62.606	.66521	.3327	.45033
300.00	2.7564	65.981	66.201	.70058	.3324	.46642
310.00	2.7080	69.629	69.861	.73644	.3320	.48232
320.00	2.6625	73.342	73.586	.77276	.3317	.49800
330.00	2.6198	77.116	77.372	.80954	.3314	.51345
340.00	2.5797	80.950	81.219	.84674	.3311	.52867
350.00	2.5418	84.843	85.125	.88436	.3308	.54362
360.00	2.5061	88.792	89.087	.92238	.3305	.55833
370.00	2.4723	92.797	93.105	.96078	.3302	.57282
380.00	2.4404	96.855	97.176	.99956	.3300	.58707
390.00	2.4101	100.97	101.30	1.0367	.3297	.60108
400.00	2.3813	105.13	105.47	1.0782	.3294	.61482
410.00	2.3540	109.34	109.70	1.1180	.3292	.62827
420.00	2.3281	113.59	113.97	1.1581	.3289	.64139
430.00	2.3034	117.90	118.29	1.1985	.3287	.65419
440.00	2.2798	122.25	122.65	1.2393	.3284	.66666
450.00	2.2574	126.64	127.06	1.2803	.3281	.67880
460.00	2.2360	131.08	131.51	1.3216	.3279	.69060
470.00	2.2155	135.56	136.00	1.3631	.3276	.70208
480.00	2.1959	140.08	140.54	1.4050	.3274	.71323
490.00	2.1772	144.64	145.11	1.4470	.3272	.72406

# CHLORINE

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	KEV/CH	GM/CM2	METER	GM/CM2	METER	GM/CM2	METER PERCENT		
500.00	2.1593	6.8304	149.24	471.77	149.72	473.31	1.4894	4.7082	.9947	.73456
510.00	2.1421	6.7761	153.67	486.42	154.37	488.01	1.5319	4.8427	.9923	.74475
520.00	2.1256	6.7240	158.54	501.19	159.06	502.83	1.5747	4.9780	.9900	.75462
530.00	2.1098	6.6740	163.25	516.07	163.78	517.76	1.6177	5.1139	.9877	.76418
540.00	2.0946	6.6260	167.99	531.06	168.54	532.79	1.6609	5.2505	.9855	.77343
550.00	2.0801	6.5799	172.77	546.15	173.33	547.94	1.7043	5.3878	.9833	.78238
560.00	2.0661	6.5356	177.58	561.36	178.15	563.19	1.7480	5.5257	.9811	.79104
570.00	2.0526	6.4930	182.42	576.66	183.01	578.54	1.7918	5.6642	.9790	.79940
580.00	2.0396	6.4520	187.29	592.06	187.90	593.99	1.8358	5.8033	.9770	.80749
590.00	2.0271	6.4125	192.19	607.56	192.82	609.54	1.8800	5.9433	.9750	.81529
600.00	2.0151	6.3745	197.12	623.15	197.76	625.18	1.9243	6.0832	.9730	.82282
620.00	1.9924	6.3026	207.07	654.61	207.75	656.73	2.0135	6.3653	.9692	.83710
640.00	1.9712	6.2356	217.13	686.41	217.84	688.64	2.1034	6.6494	.9656	.85036
660.00	1.9515	6.1733	227.30	718.55	228.04	720.88	2.1939	6.9354	.9621	.86266
680.00	1.9331	6.1151	237.57	751.00	238.33	753.43	2.2850	7.2233	.9587	.87406
700.00	1.9159	6.0607	247.93	783.75	248.73	786.28	2.3766	7.5129	.9555	.88461
720.00	1.8999	6.0099	258.38	816.79	259.21	819.42	2.4687	7.8041	.9524	.89435
740.00	1.8848	5.9622	268.91	850.10	269.78	852.84	2.5613	8.0969	.9494	.90434
760.00	1.8707	5.9175	279.53	883.67	280.43	886.51	2.6544	8.3912	.9465	.91163
780.00	1.8574	5.8755	290.23	917.48	291.16	920.43	2.7479	8.6868	.9438	.91926
800.00	1.8449	5.8361	301.00	951.54	301.97	954.59	2.8419	8.9838	.9411	.92627
820.00	1.8332	5.7989	311.85	985.82	312.84	988.97	2.9362	9.2821	.9386	.93272
840.00	1.8221	5.7640	322.76	1020.3	323.79	1023.6	3.0310	9.5816	.9361	.93864
860.00	1.8117	5.7310	333.73	1055.0	334.80	1058.4	3.1261	9.8822	.9337	.94407
880.00	1.8019	5.7000	344.77	1089.9	345.87	1093.4	3.2215	10.184	.9314	.94904
900.00	1.7926	5.6706	355.87	1125.0	357.01	1128.6	3.3173	10.487	.9292	.95360
920.00	1.7836	5.6429	367.03	1160.3	368.20	1164.0	3.4134	10.790	.9271	.95777
940.00	1.7750	5.6167	378.25	1195.7	379.45	1199.5	3.5098	11.095	.9250	.96158
960.00	1.7670	5.5920	389.53	1231.4	390.76	1235.3	3.6065	11.401	.9229	.96506
1000.00	1.7533	5.5464	412.34	1303.5	413.64	1307.6	3.8007	12.015	.9189	.97114

THE ELECTRON DENSITY OF CHLORINE IS 2.839E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.172 BEV, AND THE MINIMUM ENERGY LOSS IS 1.6347 MEV/GM/CM2

# CHROMIUM

ELEMENT CR  
ATOMIC NUMBER 24  
ATOMS/MOLECULE 1  
ATOMIC WEIGHT 51.996  
ADJUSTED IONIZATION POTENTIAL 244.4

DENSITY = 7.1900 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH MM	PROTON PATH LENGTH HG/CM2	PATH LENGTH STRAGGLING MM	PATH LENGTH STRAGGLING HG/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	400.73	.43727	.00061	.44667	.00062	.01904	2.104	0.
.15	367.72	.56698	.00079	.57688	.00080	.02138	1.716	0.
.20	337.99	.70773	.00098	.71867	.00100	.02396	1.523	0.
.30	287.65	1.0267	.00143	1.0398	.00145	.03000	1.322	0.
.40	248.17	1.3975	.00194	1.4146	.00197	.03812	1.210	0.
.50	218.01	1.8242	.00254	1.8452	.00257	.04823	1.135	0.
.60	195.63	2.3050	.00321	2.3302	.00324	.05987	1.080	0.
.70	179.50	2.8350	.00394	2.8647	.00398	.07252	1.038	0.
.80	168.08	3.4069	.00474	3.4414	.00479	.08568	1.004	0.
.90	153.53	4.0238	.00560	4.0634	.00565	.09968	.9762	0.
1.00	138.98	4.7028	.00654	4.7480	.00660	.11553	.9517	0.
1.20	124.34	6.2141	.00834	6.2714	.00872	.15038	.9131	0.
1.40	112.95	7.8910	.01097	7.9614	.01107	.18702	.8842	0.
1.60	103.88	9.7260	.01353	9.8105	.01364	.22546	.8611	0.
1.80	96.460	11.712	.01629	11.811	.01643	.26563	.8418	0.
2.00	90.217	13.841	.01925	13.956	.01941	.30748	.8253	0.
2.20	84.869	16.111	.02241	16.242	.02259	.35099	.8108	0.
2.40	80.220	18.519	.02576	18.668	.02596	.39616	.7978	0.
2.60	76.128	21.062	.02929	21.228	.02953	.44295	.7863	0.
2.80	72.489	23.736	.03301	23.922	.03327	.49139	.7758	0.
3.00	69.226	26.541	.03691	26.746	.03720	.54184	.7661	0.
3.20	66.279	29.474	.04099	29.699	.04131	.59438	.7573	0.
3.40	63.603	32.534	.04525	32.780	.04559	.64892	.7491	.00001
3.60	61.154	35.722	.04968	35.989	.05005	.70539	.7415	.00001
3.80	58.916	39.032	.05429	39.321	.05469	.76373	.7343	.00001
4.00	56.857	42.465	.05906	42.776	.05949	.82387	.7277	.00001
4.20	54.956	46.021	.06401	46.356	.06447	.88576	.7214	.00002
4.40	53.196	49.697	.06912	50.055	.06962	.94935	.7155	.00002
4.60	51.562	53.492	.07440	53.874	.07493	1.0146	.7100	.00003
4.80	50.039	57.405	.07984	57.813	.08041	1.0815	.7047	.00004

CHROMIUM

PRCTCN ENERGY MEV	ENERGY LOSS MEV/ GM*CM2	PROTON RANGE GM*CM2	CH	TOTON PATH LENGTH GM/CM2	CH	PATH LENGTH STRAGGLING GM/CM2	CH	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	43.617	349.55	.06143	.06187	.00860	.00115	.00016	1.859	.598	.00064
5.50	45.429	326.63	.07201	.07251	.01009	.00133	.00018	1.831	.684	.00007
6.00	42.658	306.78	.08331	.08388	.01159	.00152	.00021	1.807	.682	.00010
6.50	40.258	289.45	.09531	.09595	.01334	.00171	.00024	1.784	.692	.00013
7.00	38.132	274.17	.10800	.10872	.01512	.00192	.00027	1.764	.660	.00018
7.50	36.283	260.87	.12136	.12216	.01699	.00213	.00030	1.746	.656	.00023
8.00	34.620	248.92	.13540	.13628	.01895	.00236	.00033	1.728	.648	.00029
8.50	33.120	238.13	.15008	.15104	.02101	.00259	.00036	1.712	.640	.00035
9.00	31.759	228.34	.16541	.16646	.02315	.00282	.00039	1.697	.6349	.00043
9.50	30.518	219.42	.18138	.18253	.02539	.00307	.00043	1.683	.6296	.00051
10.00	29.381	211.25	.19797	.19922	.02771	.00333	.00046	1.670	.6247	.00060
11.00	27.369	196.78	.23307	.23452	.03262	.00386	.00054	1.645	.6157	.00080
12.00	25.643	184.37	.27064	.27229	.03787	.00442	.00061	1.623	.6079	.00111
13.00	24.143	173.59	.31063	.31250	.04346	.00501	.00070	1.604	.6009	.00261
14.00	22.827	164.13	.35300	.35511	.04939	.00563	.00078	1.587	.5946	.00509
15.00	21.663	155.76	.39775	.40011	.05565	.00628	.00087	1.570	.5889	.00761
16.00	20.625	148.30	.44481	.44742	.06185	.00696	.00097	1.556	.5838	.01015
17.00	19.693	141.60	.49418	.49706	.06913	.00767	.00107	1.542	.5791	.01270
18.00	18.852	135.54	.54593	.54898	.07635	.00840	.00117	1.530	.5748	.01528
19.00	18.088	130.05	.59971	.60315	.08389	.00916	.00127	1.518	.5708	.01788
20.00	17.390	125.04	.65580	.65954	.09173	.00994	.00138	1.507	.5671	.02049
22.00	16.164	116.22	.77455	.77892	.10833	.01159	.00161	1.488	.5605	.02578
24.00	15.118	108.70	.90192	.90695	.12614	.01334	.00185	1.470	.5547	.03113
26.00	14.214	102.20	1.0377	1.0435	.14513	.01518	.00211	1.453	.5496	.03464
28.00	13.426	96.533	1.1818	1.1883	.16527	.01712	.00238	1.441	.5450	.03623
30.00	12.730	91.531	1.3341	1.3414	.18656	.01915	.00266	1.428	.5410	.03788
32.00	12.113	87.094	1.4944	1.5025	.20897	.02128	.00296	1.416	.5373	.03960
34.00	11.561	83.123	1.6626	1.6715	.23248	.02349	.00327	1.403	.5339	.04138
36.00	11.064	79.547	1.8386	1.8484	.25708	.02579	.00359	1.393	.5309	.04322
38.00	10.613	76.308	2.0223	2.0330	.28276	.02817	.00392	1.386	.5280	.04512
40.00	10.203	73.360	2.2136	2.2253	.30950	.03064	.00426	1.377	.5254	.04707
45.00	9.3221	67.026	2.7244	2.7386	.38089	.03717	.00517	1.357	.5198	.05217
50.00	8.6012	61.843	3.2806	3.2976	.45863	.04420	.00615	1.340	.5150	.05753
55.00	7.9996	57.517	3.8809	3.9008	.54254	.05169	.00719	1.325	.5109	.06316
60.00	7.4894	53.849	4.5242	4.5473	.63244	.05965	.00830	1.312	.5073	.06906
65.00	7.0511	50.697	5.2093	5.2357	.72819	.06804	.00946	1.300	.5042	.07518
70.00	6.6694	47.953	5.9353	5.9652	.82965	.07665	.01069	1.289	.5015	.08150
75.00	6.3353	45.551	6.7011	6.7348	.93668	.08609	.01197	1.278	.4991	.08801
80.00	6.0397	43.425	7.5058	7.5433	1.0491	.09572	.01331	1.269	.4969	.09466
90.00	5.5395	39.829	9.2286	9.2744	1.2899	.11611	.01615	1.252	.4931	.10834



# CHROMIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	CH	PROTON PATH LENGTH CM GM/CM2	GH/CM2	PATH LENGTH STRAGGLING CM PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	5.1322	36.900	11.097	11.152	1.5510	1.3795	1.237	.1237
110.00	4.7939	34.468	13.105	13.169	1.8316	.0241	1.224	.13682
120.00	4.5083	32.415	15.248	15.322	2.1310	.02582	1.212	.15181
130.00	4.2639	30.658	17.519	17.604	2.4484	.02940	1.201	.16725
140.00	4.0524	29.137	19.915	20.011	2.7832	.03313	1.190	.18305
150.00	3.8674	27.807	22.430	22.518	3.1346	.03702	1.181	.19914
160.00	3.7044	26.635	25.060	25.181	3.5022	.04105	1.172	.21549
170.00	3.5595	25.593	27.802	27.936	3.8853	.04523	1.164	.23209
180.00	3.4300	24.662	30.652	30.798	4.2835	.04953	1.156	.24887
190.00	3.3135	23.824	33.605	33.765	4.6962	.05396	1.149	.26577
200.00	3.2082	23.067	36.658	36.833	5.1228	.05850	1.142	.28276
210.00	3.1125	22.379	39.809	39.998	5.5631	.06316	1.135	.29978
220.00	3.0252	21.751	43.053	43.258	6.0164	.06793	1.129	.31679
230.00	2.9452	21.176	46.389	46.609	6.4824	.07281	1.123	.33375
240.00	2.8717	20.647	49.812	50.048	6.9607	.07778	1.117	.35063
250.00	2.8039	20.160	53.320	53.572	7.4509	.08284	1.112	.36739
260.00	2.7412	19.709	56.911	57.180	7.9527	.08800	1.107	.38406
270.00	2.6831	19.291	60.582	60.867	8.4656	.09325	1.101	.40064
280.00	2.6290	18.902	64.330	64.633	8.9893	.09858	1.097	.41712
290.00	2.5786	18.540	68.153	68.474	9.5235	.10399	1.092	.43347
300.00	2.5315	18.202	72.050	72.388	10.068	.10947	1.087	.44966
310.00	2.4875	17.885	76.017	76.374	10.622	.11503	1.083	.46565
320.00	2.4462	17.588	80.052	80.428	11.184	.12066	1.079	.48142
330.00	2.4074	17.309	84.155	84.549	11.759	.12636	1.075	.49694
340.00	2.3708	17.046	88.322	88.735	12.341	.13212	1.071	.51221
350.00	2.3364	16.799	92.551	92.984	12.932	.13795	1.067	.52720
360.00	2.3039	16.565	96.842	97.295	13.532	.14383	1.063	.54197
370.00	2.2732	16.344	101.19	101.66	14.140	.14978	1.059	.55655
380.00	2.2441	16.135	105.60	106.09	14.756	.15578	1.056	.57093
390.00	2.2166	15.937	110.06	110.58	15.379	.16183	1.052	.58509
400.00	2.1905	15.749	114.58	115.11	16.010	.16794	1.049	.59902
410.00	2.1656	15.571	119.15	119.71	16.649	.17409	1.046	.61268
420.00	2.1420	15.401	123.77	124.35	17.295	.18030	1.043	.62602
430.00	2.1196	15.240	128.45	129.04	17.948	.18655	1.039	.63903
440.00	2.0981	15.086	133.17	133.78	18.607	.19284	1.036	.65173
450.00	2.0777	14.939	137.93	138.57	19.273	.19918	1.033	.66410
460.00	2.0582	14.799	142.75	143.41	19.946	.20556	1.031	.67614
470.00	2.0396	14.665	147.61	148.29	20.625	.21198	1.028	.68786
480.00	2.0218	14.537	152.51	153.22	21.310	.21844	1.025	.69926
490.00	2.0048	14.415	157.45	158.18	22.000	.22494	1.022	.71033

# CHROMIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GM/CH2	MEV/CH	GM/CH2	CH	GM/CH2	CH	GM/CH2	PERCENT			
500.00	1.9885	14.297	162.44	22.592	163.19	22.697	1.6643	.23147	1.020	.4606	.72109
510.00	1.9729	14.135	167.47	23.292	168.24	23.399	1.7115	.23804	1.017	.4602	.73153
520.00	1.9579	14.077	172.53	23.996	173.33	24.107	1.7590	.24465	1.015	.4599	.74166
530.00	1.9435	13.974	177.63	24.706	178.46	24.820	1.8067	.25128	1.012	.4596	.75147
540.00	1.9298	13.875	182.78	25.421	183.62	25.538	1.8546	.25795	1.010	.4593	.76099
550.00	1.9165	13.780	187.95	26.141	188.82	26.261	1.9028	.26455	1.008	.4590	.77020
560.00	1.9038	13.688	193.16	26.866	194.05	26.989	1.9512	.27137	1.005	.4587	.77912
570.00	1.8915	13.600	198.41	27.595	199.32	27.722	1.9998	.27813	1.003	.4584	.78775
580.00	1.8798	13.515	203.69	28.330	204.63	28.460	2.0485	.28491	1.001	.4581	.79609
590.00	1.8684	13.434	209.00	29.060	209.96	29.202	2.0975	.29173	.9990	.4578	.80416
600.00	1.8575	13.355	214.35	29.812	215.33	29.949	2.1467	.29856	.9969	.4575	.81195
	1.8368	13.207	225.13	31.311	226.16	31.455	2.2456	.31232	.9929	.4568	.82674
	1.8176	13.069	236.02	32.827	237.11	32.977	2.3451	.32616	.9891	.4562	.84052
	1.7997	12.940	247.03	34.358	248.16	34.515	2.4453	.34010	.9854	.4556	.85332
	1.7831	12.820	258.15	35.904	259.33	36.068	2.5462	.35413	.9818	.4550	.86522
	1.7675	12.708	269.37	37.464	270.60	37.635	2.6476	.36823	.9784	.4544	.87624
	1.7529	12.603	280.68	39.038	281.96	39.215	2.7495	.38241	.9752	.4537	.88645
	1.7392	12.505	292.09	40.624	293.41	40.809	2.8520	.39666	.9720	.4531	.89589
	1.7264	12.413	303.58	42.222	304.96	42.414	2.9550	.41098	.9690	.4525	.90461
	1.7144	12.326	315.15	43.832	316.58	44.031	3.0584	.42537	.9661	.4519	.91266
800.00	1.7031	12.245	326.81	45.453	328.29	45.659	3.1623	.43982	.9633	.4512	.92008
	1.6925	12.169	338.54	47.085	340.07	47.296	3.2666	.45432	.9606	.4506	.92691
	1.6825	12.097	350.34	48.726	351.92	48.946	3.3713	.46889	.9580	.4500	.93319
	1.6731	12.029	362.21	50.377	363.85	50.605	3.4764	.48350	.9554	.4493	.93897
	1.6642	11.965	374.15	52.038	375.84	52.272	3.5818	.49817	.9530	.4487	.94428
	1.6558	11.905	386.15	53.707	387.89	53.949	3.6876	.51288	.9507	.4480	.94915
	1.6479	11.848	398.22	55.385	400.01	55.634	3.7937	.52764	.9484	.4473	.95362
	1.6404	11.795	410.35	57.072	412.19	57.328	3.9002	.54245	.9462	.4466	.95771
	1.6334	11.744	422.54	58.768	424.43	59.031	4.0070	.55730	.9441	.4457	.96146
	1.6204	11.651	447.21	62.199	449.21	62.476	4.2213	.58711	.9397	.4436	.96803

THE ELECTRON DENSITY OF CHROMIUM IS 2.701E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.117 SEV, AND THE MINIMUM ENERGY LOSS IS 1.5127 MEV/GM/CH2

## COBALT

ELEMENT CO  
 ATOMIC NUMBER 27  
 ATOMS/MOLECULE 1  
 ATOMIC WEIGHT 58.933  
 ADJUSTED IONIZATION POTENTIAL 292.5

DENSITY = 8.9000 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH MM	PROTON PATH LENGTH MM	PATH LENGTH STRAGGLING MM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	301.05	.48287	.00054	.49426	.02147	2.305	0.
.15	290.59	.65103	.00073	.66330	.02596	1.850	0.
.20	264.16	.82961	.00093	.84367	.03043	2.666	0.
.30	232.36	1.2301	.00138	1.2489	.04012	1.506	0.
.40	200.93	1.6861	.00169	1.7105	.05076	1.424	0.
.50	177.74	2.2122	.00249	2.2429	.06420	1.366	0.
.60	170.09	2.7816	.00313	2.8189	.07837	1.322	0.
.70	155.77	3.3866	.00381	3.4307	.09279	1.285	0.
.80	145.71	4.0437	.00454	4.0949	.10844	1.252	0.
.90	136.65	4.7453	.00533	4.8039	.12479	1.222	0.
1.00	127.58	5.4942	.00617	5.5606	.14213	1.194	0.
1.20	114.41	7.1370	.00802	7.2197	.17950	1.146	0.
1.40	104.22	8.9543	.01006	9.0546	.21969	1.108	0.
1.60	96.099	10.937	.01229	11.056	.26202	1.075	0.
1.80	89.354	13.078	.01469	13.217	.30646	1.046	0.
2.00	83.669	15.373	.01727	15.531	.35293	1.022	0.
2.20	78.791	17.815	.02002	17.995	.40134	.9999	0.
2.40	74.575	20.404	.02293	20.606	.45156	.9803	0.
2.60	70.863	23.134	.02599	23.359	.50355	.9629	0.
2.80	67.563	26.002	.02922	26.251	.55728	.9473	0.
3.00	64.639	29.004	.03259	29.277	.61267	.9328	0.
3.20	61.964	32.139	.03611	32.437	.66970	.9197	0.
3.40	59.534	35.406	.03978	35.731	.72842	.9076	0.
3.60	57.313	38.806	.04360	39.157	.78979	.8964	0.
3.80	55.273	42.332	.04756	42.711	.85116	.8859	.00001
4.00	53.392	45.919	.05167	46.392	.91559	.8763	.00001
4.20	51.651	49.767	.05592	50.203	.98201	.8671	.00001
4.40	50.033	53.673	.06031	54.138	1.0504	.8587	.00001
4.60	48.526	57.701	.06483	58.196	1.1206	.8506	.00002
4.80	47.119	61.854	.06950	62.380	1.1926	.8431	.00002

## COBALT

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GH/CH2	HEV/CH	GH/CH2	CM	GH/CH2	CM	GH/CH2	PERCENT		
5.00	45.798	407.60	.06613	.00743	.06669	.00749	.00127	.00014	1.892	.00003
5.50	42.847	381.33	.07734	.00869	.07798	.00876	.00146	.00016	1.870	.00005
6.00	40.301	358.68	.08929	.01003	.09002	.01011	.00166	.00019	1.845	.00007
6.50	38.079	338.91	.10198	.01146	.10279	.01155	.00187	.00021	1.823	.00010
7.00	36.119	321.46	.11537	.01296	.11628	.01306	.00210	.00024	1.802	.00014
7.50	34.369	305.69	.12947	.01455	.13047	.01466	.00233	.00026	1.783	.00018
8.00	32.795	291.68	.14426	.01621	.14537	.01633	.00257	.00029	1.766	.00023
8.50	31.376	279.24	.15975	.01795	.16096	.01809	.00282	.00032	1.750	.00029
9.00	30.115	268.03	.17591	.01977	.17723	.01991	.00307	.00035	1.735	.00035
9.50	28.928	257.46	.19275	.02166	.19418	.02182	.00334	.00038	1.721	.00042
10.00	27.869	248.04	.21025	.02362	.21180	.02380	.00362	.00041	1.708	.00050
11.00	25.994	231.34	.24710	.02777	.24898	.02798	.00419	.00047	1.683	.00068
12.00	24.381	216.99	.28668	.03221	.28872	.03244	.00480	.00054	1.661	.00093
13.00	22.978	204.51	.32868	.03693	.33099	.03719	.00543	.00061	1.641	.00175
14.00	21.745	193.53	.37315	.04193	.37575	.04222	.00610	.00069	1.623	.00259
15.00	20.652	183.80	.42007	.04720	.42296	.04752	.00679	.00076	1.606	.00467
16.00	19.675	175.11	.46939	.05274	.47259	.05310	.00752	.00084	1.591	.00740
17.00	18.797	167.30	.52109	.05855	.52461	.05895	.00827	.00093	1.577	.00985
18.00	18.003	160.23	.57512	.06462	.57897	.06505	.00906	.00102	1.564	.01232
19.00	17.282	153.61	.63149	.07095	.63569	.07143	.00987	.00111	1.552	.01461
20.00	16.623	147.94	.69015	.07755	.69471	.07806	.01070	.00120	1.541	.01731
22.00	15.462	137.61	.81425	.09149	.81955	.09208	.01246	.00140	1.520	.02238
24.00	14.471	128.79	.94723	.10643	.95333	.10712	.01432	.00161	1.502	.02753
26.00	13.614	121.17	1.0890	.12236	1.0959	.12314	.01628	.00183	1.486	.03092
28.00	12.866	114.51	1.2393	.13925	1.2471	.14012	.01834	.00206	1.471	.03250
30.00	12.206	108.63	1.3980	.15708	1.4068	.15806	.02050	.00230	1.457	.03415
32.00	11.619	103.41	1.5650	.17585	1.5748	.17694	.02276	.00256	1.445	.03586
34.00	11.093	98.731	1.7403	.19593	1.7510	.19674	.02510	.00282	1.434	.03763
36.00	10.620	94.517	1.9235	.21612	1.9353	.21745	.02754	.00309	1.423	.03947
38.00	10.191	90.699	2.1147	.23761	2.1276	.23906	.03007	.00338	1.413	.04136
40.00	9.7997	87.218	2.3138	.25997	2.3278	.26155	.03268	.00367	1.404	.04330
45.00	8.9602	79.746	2.8450	.31966	2.8620	.32158	.03959	.00445	1.383	.04837
50.00	8.2724	73.625	3.4231	.38461	3.4434	.38690	.04702	.00528	1.365	.05370
55.00	7.6980	68.512	4.0467	.45468	4.0705	.45735	.05493	.00617	1.350	.05930
60.00	7.2106	64.174	4.7145	.52972	4.7420	.53281	.06333	.00712	1.335	.06517
65.00	6.7915	60.444	5.4255	.60960	5.4569	.61314	.07217	.00811	1.323	.07129
70.00	6.4270	57.200	6.1785	.69421	6.2141	.69821	.08147	.00915	1.311	.07762
75.00	6.1067	54.350	6.9726	.78344	7.0126	.78793	.08918	.01025	1.300	.08415
80.00	5.8234	51.828	7.8068	.87717	7.8513	.88217	.10132	.01138	1.290	.09085
90.00	5.3437	47.559	9.5919	1.0777	9.6462	1.0838	.12277	.01379	1.273	.10467

## COBALT

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CH	GM/CM2	CH PERCENT		
100.00	4.9533	11.527	1.2952	11.592	1.3024	.14572	.01637	1.257	.11893
110.00	4.6287	13.606	1.5288	13.682	1.5373	.17009	.01911	1.243	.13363
120.00	4.3546	15.823	1.7778	15.911	1.7877	.19579	.02200	1.231	.14883
130.00	4.1199	18.172	2.0418	18.273	2.0531	.22276	.02503	1.218	.16442
140.00	3.9166	20.650	2.3202	20.763	2.3330	.25092	.02819	1.208	.18032
150.00	3.7389	23.250	2.6124	23.378	2.6267	.28023	.03149	1.199	.19645
160.00	3.5821	25.969	2.9179	26.111	2.9338	.31061	.03490	1.190	.21281
170.00	3.4428	28.802	3.2362	28.960	3.2539	.34202	.03843	1.181	.22943
180.00	3.3182	31.746	3.5670	31.919	3.5864	.37440	.04207	1.173	.24623
190.00	3.2061	34.797	3.9097	34.986	3.9310	.40772	.04581	1.165	.26318
200.00	3.1047	37.950	4.2641	38.156	4.2872	.44192	.04965	1.158	.28021
210.00	3.0126	41.203	4.6296	41.426	4.6546	.47697	.05359	1.151	.29730
220.00	2.9285	44.553	5.0060	44.794	5.0330	.51283	.05762	1.145	.31443
230.00	2.8515	47.996	5.3928	48.255	5.4219	.54946	.06174	1.139	.33156
240.00	2.7807	51.529	5.7898	51.806	5.8209	.58683	.06594	1.133	.34865
250.00	2.7154	55.150	6.1966	55.446	6.2299	.62490	.07021	1.127	.36566
260.00	2.6550	58.855	6.6129	59.171	6.6484	.66366	.07457	1.122	.38257
270.00	2.5990	62.642	7.0385	62.978	7.0762	.70305	.07899	1.116	.39935
280.00	2.5469	66.509	7.4729	66.865	7.5129	.74307	.08349	1.111	.41598
290.00	2.4984	70.453	7.9161	70.830	7.9584	.78368	.08805	1.106	.43242
300.00	2.4530	74.472	8.3676	74.870	8.4123	.82487	.09268	1.102	.44867
310.00	2.4105	78.563	8.8273	78.982	8.8744	.86660	.09737	1.097	.46471
320.00	2.3707	82.725	9.2949	83.166	9.3445	.90885	.10212	1.093	.48054
330.00	2.3333	86.955	9.7702	87.418	9.8222	.95161	.10692	1.089	.49614
340.00	2.2981	91.251	10.253	91.737	10.307	.99485	.11178	1.084	.51150
350.00	2.2649	95.612	10.743	96.120	10.800	1.0386	.11669	1.080	.52661
360.00	2.2336	100.03	11.240	100.57	11.300	1.0827	.12165	1.077	.54148
370.00	2.2040	104.52	11.744	105.07	11.806	1.1273	.12666	1.073	.55611
380.00	2.1760	109.06	12.254	109.64	12.319	1.1723	.13172	1.069	.57050
390.00	2.1494	113.66	12.771	114.26	12.839	1.2177	.13682	1.066	.58453
400.00	2.1242	118.32	13.294	118.94	13.365	1.2635	.14196	1.062	.59850
410.00	2.1003	123.03	13.823	123.68	13.896	1.3096	.14715	1.059	.61207
420.00	2.0776	127.79	14.358	128.47	14.434	1.3561	.15237	1.056	.62534
430.00	2.0559	132.60	14.899	133.30	14.978	1.4030	.15764	1.052	.63829
440.00	2.0353	137.47	15.446	138.19	15.527	1.4502	.16294	1.049	.65093
450.00	2.0156	142.38	15.995	143.13	16.082	1.4977	.16828	1.046	.66325
460.00	1.9968	147.34	16.555	148.12	16.642	1.5455	.17365	1.043	.67525
470.00	1.9788	152.34	17.117	153.15	17.207	1.5936	.17905	1.041	.68693
480.00	1.9617	157.39	17.685	158.22	17.778	1.6420	.18449	1.038	.69830
490.00	1.9453	162.49	18.257	163.34	18.353	1.6906	.18996	1.035	.70934

## COBALT

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
500.00	1.9296	17.173	167.62	18.634	168.50	18.933	1.7396	.19546	.5228	.72008
510.00	1.9145	17.039	172.80	19.416	173.71	19.518	1.7888	.20099	.5224	.73050
520.00	1.9001	16.911	178.01	20.092	178.95	20.107	1.8382	.20654	.5220	.74062
530.00	1.8862	16.788	183.27	20.592	184.23	20.700	1.8879	.21213	.5217	.75042
540.00	1.8739	16.649	188.56	21.187	189.55	21.298	1.9378	.21774	.5213	.75993
550.00	1.8602	16.556	193.89	21.786	194.91	21.900	1.9880	.22337	.5210	.76915
560.00	1.8479	16.446	199.26	22.389	200.30	22.506	2.0384	.22903	.5206	.77807
570.00	1.8361	16.342	204.66	22.996	205.73	23.116	2.0889	.23471	.5203	.78670
580.00	1.8248	16.241	210.10	23.606	211.20	23.730	2.1397	.24042	.5199	.79505
590.00	1.8139	16.143	215.57	24.221	216.69	24.347	2.1907	.24615	.5196	.80313
600.00	1.8033	16.050	221.07	24.839	222.22	24.969	2.2419	.25190	.5192	.81094
620.00	1.7834	15.873	232.16	26.086	233.37	26.222	2.3448	.26346	.5185	.82376
640.00	1.7649	15.708	243.38	27.346	244.65	27.488	2.4484	.27511	.5178	.83957
660.00	1.7477	15.555	254.71	28.619	256.04	28.768	2.5527	.28682	.5172	.85242
680.00	1.7316	15.412	266.15	29.905	267.53	30.060	2.6576	.29861	.5165	.86436
700.00	1.7166	15.278	277.69	31.202	279.13	31.363	2.7631	.31046	.5158	.87544
720.00	1.7026	15.153	289.33	32.510	290.83	32.678	2.8692	.32238	.5151	.88570
740.00	1.6894	15.036	301.07	33.828	302.63	34.003	2.9758	.33436	.5144	.89519
760.00	1.6771	14.926	312.89	35.156	314.51	35.338	3.0828	.34639	.5137	.90397
780.00	1.6656	14.823	324.80	36.494	326.48	36.683	3.1904	.35847	.5130	.91207
800.00	1.6547	14.727	336.79	37.842	338.52	38.036	3.2984	.37061	.5123	.91954
820.00	1.6443	14.636	348.86	39.197	350.65	39.399	3.4068	.38279	.5116	.92642
840.00	1.6349	14.550	361.00	40.561	362.85	40.770	3.5157	.39502	.5108	.93276
860.00	1.6258	14.470	373.21	41.933	375.12	42.148	3.6249	.40729	.5101	.93858
880.00	1.6173	14.394	385.48	43.313	387.46	43.534	3.7345	.41960	.5094	.94393
900.00	1.6093	14.323	397.83	44.700	399.86	44.928	3.8444	.43196	.5087	.94885
920.00	1.6017	14.255	410.23	46.094	412.33	46.329	3.9547	.44435	.5079	.95335
940.00	1.5945	14.191	422.70	47.495	424.86	47.737	4.0653	.45678	.5071	.95748
960.00	1.5878	14.131	435.24	48.904	437.46	49.153	4.1762	.46924	.5061	.96126
1000.00	1.5753	14.020	460.61	51.754	462.94	52.016	4.3989	.49426	.5037	.96789

THE ELECTRON DENSITY OF COBALT IS 2.760E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.088 BEV, AND THE MINIMUM ENERGY LOSS IS 1.4775 MEV/GM/CM2

## COPPER

ADJUSTED  
IONIZATION  
POTENTIAL  
320.0

ATOMIC  
WEIGHT  
63.540

ATOMS/  
MOLECULE  
1

ATOMIC  
NUMBER  
29

ELEMENT  
CU

DENSITY = 8.9200 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS HEV/CH2	PROTON RANGE MG/CM2	PROTON PATH LENGTH MM	MG/CM2	PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
					MG/CM2	PERCENT		
.10	225.66	2012.9	.51904	.53200	.02338	.00003	2.436	0.
.15	227.21	2026.7	.73833	.75281	.03226	.00004	1.924	0.
.20	221.45	1975.3	.95829	.97569	.03926	.00004	1.784	0.
.30	200.95	1792.5	1.4250	1.4494	.05190	.00006	1.689	0.
.40	182.31	1626.2	1.9401	1.9724	.06457	.00007	1.635	0.
.50	167.45	1493.7	2.5047	2.5452	.07779	.00009	1.588	0.
.60	154.86	1381.4	3.1175	3.1664	.09246	.00010	1.544	0.
.70	144.04	1284.8	3.7782	3.8358	.10840	.00012	1.502	0.
.80	135.27	1206.6	4.4857	4.5523	.12533	.00014	1.463	0.
.90	128.44	1145.7	5.2348	5.3105	.14287	.00016	1.427	0.
1.00	121.60	1084.6	6.0257	6.1109	.16098	.00018	1.394	0.
1.20	109.47	976.47	7.7424	7.9471	.19970	.00022	1.335	0.
1.40	99.835	890.53	9.6373	9.7627	.24155	.00027	1.284	0.
1.60	92.062	821.19	11.704	11.851	.28617	.00032	1.241	0.
1.80	85.765	765.02	13.935	14.105	.33318	.00037	1.203	0.
2.00	80.408	717.24	16.321	16.514	.38231	.00043	1.171	0.
2.20	75.782	675.97	18.859	19.076	.43350	.00049	1.142	0.
2.40	71.762	640.11	21.548	21.791	.48667	.00055	1.116	0.
2.60	68.214	608.47	24.379	24.649	.54174	.00061	1.093	0.
2.80	65.080	580.51	27.355	27.652	.59864	.00067	1.073	0.
3.00	62.325	555.94	30.471	30.796	.65729	.00074	1.054	0.
3.20	59.778	533.22	33.718	34.071	.71754	.00080	1.037	0.
3.40	57.464	512.58	37.105	37.488	.77953	.00087	1.022	0.
3.60	55.350	493.72	40.622	41.035	.84322	.00095	1.007	0.
3.80	53.408	476.40	44.267	44.712	.90859	.00102	.9941	0.
4.00	51.618	460.43	48.044	48.521	.97562	.00109	.9818	.00001
4.20	49.959	445.64	51.954	52.463	1.0443	.00117	.9703	.00001
4.40	48.419	431.89	55.984	56.526	1.1150	.00125	.9595	.00001
4.60	46.982	419.08	60.145	60.722	1.1878	.00133	.9495	.00001
4.80	45.639	407.10	64.430	65.042	1.2624	.00142	.9400	.00002

## COPPER

PRCTGN ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH GM/CH2		PATH LENGTH STRAGGLING GM/CH2		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/CH2	MEV/CM	GM/CH2	CM	GM/CH2	CM	GM/CH2	CM		
5.00	44.381	395.87	.06884	.00772	.06949	.00779	.00134	.00015	1.927	.00002
5.50	41.553	370.65	.08040	.00901	.08114	.00910	.00154	.00017	1.896	.00003
6.00	39.105	348.82	.09271	.01039	.09355	.01049	.00175	.00020	1.870	.00005
6.50	36.863	329.71	.10577	.01186	.10671	.01196	.00197	.00022	1.846	.00008
7.00	35.076	312.88	.11955	.01340	.12059	.01352	.00220	.00025	1.825	.00011
7.50	33.399	297.92	.13406	.01503	.13521	.01516	.00244	.00027	1.806	.00015
8.00	31.894	284.49	.14927	.01673	.15053	.01688	.00269	.00030	1.788	.00019
8.50	30.533	272.36	.16518	.01852	.16656	.01867	.00295	.00033	1.772	.00025
9.00	29.294	261.31	.18178	.02038	.18329	.02055	.00322	.00036	1.756	.00031
9.50	28.161	251.19	.19907	.02232	.20070	.02250	.00350	.00039	1.742	.00037
10.00	27.123	241.94	.21764	.02433	.21879	.02453	.00378	.00042	1.729	.00045
11.00	25.292	225.60	.25497	.02881	.25700	.02881	.00436	.00049	1.704	.00062
12.00	23.738	211.74	.29552	.03313	.29783	.03339	.00501	.00056	1.682	.00083
13.00	22.384	199.67	.33862	.03796	.34123	.03825	.00567	.00064	1.662	.00123
14.00	21.194	189.05	.38424	.04308	.38717	.04340	.00637	.00071	1.644	.00167
15.00	20.138	179.63	.43234	.04847	.43560	.04883	.00709	.00079	1.627	.00271
16.00	19.193	171.20	.48289	.05414	.48649	.05454	.00784	.00088	1.612	.00507
17.00	18.344	163.63	.53584	.06007	.53979	.06051	.00862	.00097	1.597	.00746
18.00	17.575	156.77	.59117	.06627	.59549	.06676	.00943	.00106	1.584	.00986
19.00	16.875	150.53	.64888	.07274	.65358	.07327	.01027	.00115	1.571	.01228
20.00	16.236	144.83	.70889	.07947	.71398	.08004	.01114	.00125	1.560	.01472
22.00	15.109	134.77	.83587	.09371	.84180	.09437	.01295	.00145	1.539	.01965
24.00	14.146	126.18	.97189	.10896	.97870	.10972	.01488	.00167	1.520	.02466
26.00	13.313	118.75	1.1168	.12520	1.1245	.12607	.01690	.00190	1.503	.02798
28.00	12.585	112.26	1.2704	.14242	1.2791	.14340	.01903	.00213	1.488	.02955
30.00	11.942	106.52	1.4326	.16060	1.4423	.16169	.02126	.00238	1.474	.03120
32.00	11.371	101.43	1.6032	.17973	1.6140	.18094	.02359	.00264	1.461	.03290
34.00	10.859	96.860	1.7821	.19979	1.7941	.20113	.02601	.00292	1.450	.03467
36.00	10.397	92.745	1.9692	.22076	1.9823	.22223	.02852	.00320	1.439	.03650
38.00	9.9753	89.015	2.1644	.24265	2.1787	.24425	.03113	.00349	1.429	.03838
40.00	9.5984	85.618	2.3675	.26542	2.3831	.26716	.03382	.00379	1.419	.04032
45.00	8.7703	78.311	2.9096	.32819	2.9285	.32830	.04094	.00459	1.398	.04536
50.00	8.1076	72.320	3.4993	.39229	3.5217	.39481	.04858	.00545	1.379	.05068
55.00	7.5469	67.316	4.1352	.46358	4.1615	.46653	.05673	.00636	1.363	.05325
60.00	7.0708	63.072	4.8160	.53991	4.8464	.54332	.06536	.00733	1.349	.06211
65.00	6.6614	59.420	5.5406	.62114	5.5753	.62503	.07446	.00835	1.335	.07455
70.00	6.3052	56.243	6.3079	.70716	6.3472	.71157	.08400	.00942	1.323	.08109
75.00	5.9924	53.452	7.1169	.79786	7.1610	.80280	.09399	.01054	1.312	.08781
80.00	5.7151	50.979	7.9666	.89312	8.0157	.89862	.10439	.01170	1.302	.09781
90.00	5.2461	46.795	9.7844	1.0969	9.8442	1.1036	.12641	.01417	1.284	.10171



## COPPER

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM <sup>2</sup>	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH GM/CM <sup>2</sup>	PATH LENGTH STRAGGLING GM/CM <sup>2</sup>	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	4.8636	11.755	11.826	1.4997	0.1681	1.268	.11602
110.00	4.5461	13.870	13.954	1.7497	0.1961	1.254	.13094
120.00	4.2777	16.126	16.223	2.0132	0.2257	1.241	.14625
130.00	4.0479	18.517	18.627	2.2897	0.2567	1.229	.16193
140.00	3.8488	21.037	21.162	2.5783	0.2890	1.218	.17788
150.00	3.6746	23.682	23.822	2.8785	0.3227	1.208	.19402
160.00	3.5210	26.447	26.603	3.1898	0.3576	1.199	.21039
170.00	3.3845	29.328	29.501	3.5114	0.3937	1.190	.22701
180.00	3.2623	32.321	32.511	3.8430	0.4308	1.182	.24383
190.00	3.1524	35.423	35.630	4.1841	0.4691	1.174	.26080
200.00	3.0530	38.628	38.854	4.5342	0.5083	1.167	.27785
210.00	2.9627	41.935	42.180	4.8929	0.5485	1.160	.29499
220.00	2.8803	45.339	45.603	5.2599	0.5897	1.153	.31219
230.00	2.8047	48.838	49.122	5.6347	0.6317	1.147	.32941
240.00	2.7353	52.429	52.733	6.0173	0.6746	1.141	.34662
250.00	2.6713	56.108	56.433	6.4065	0.7182	1.135	.36378
260.00	2.6120	59.873	60.219	6.8029	0.7627	1.130	.38083
270.00	2.5571	63.720	64.088	7.2058	0.8078	1.124	.39773
280.00	2.5060	67.649	68.039	7.6151	0.8537	1.119	.41444
290.00	2.4583	71.656	72.069	8.0304	0.9003	1.114	.43095
300.00	2.4138	75.738	76.174	8.4514	0.9475	1.109	.44723
310.00	2.3722	79.894	80.353	8.8781	0.9953	1.105	.46330
320.00	2.3331	84.121	84.604	9.3100	1.0437	1.100	.47918
330.00	2.2964	88.417	88.925	9.7471	1.0927	1.096	.49483
340.00	2.2619	92.781	93.313	1.0189	1.1423	1.092	.51026
350.00	2.2293	97.209	97.766	1.0636	1.1924	1.088	.52544
360.00	2.1986	101.70	102.28	1.1087	1.2430	1.084	.54037
370.00	2.1695	106.25	106.86	1.1543	1.2940	1.080	.55504
380.00	2.1420	110.87	111.50	1.2003	1.3456	1.076	.56944
390.00	2.1160	115.54	116.20	1.2467	1.3976	1.073	.58357
400.00	2.0912	120.27	120.95	1.2934	1.4500	1.069	.59741
410.00	2.0677	125.05	125.76	1.3406	1.5029	1.066	.61095
420.00	2.0454	129.88	130.62	1.3881	1.5562	1.063	.62419
430.00	2.0242	134.77	135.54	1.4360	1.6098	1.059	.63711
440.00	2.0039	139.71	140.50	1.4842	1.6639	1.056	.64973
450.00	1.9846	144.70	145.52	1.5327	1.7182	1.053	.66203
460.00	1.9662	149.73	150.58	1.5815	1.7730	1.050	.67402
470.00	1.9486	154.81	155.69	1.6306	1.8281	1.047	.68569
480.00	1.9317	159.94	160.84	1.6801	1.8835	1.045	.69705
490.00	1.9156	165.11	166.04	1.7298	1.9392	1.042	.70809

COPPER

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GH/CM2	CM	GH/CM2	CM	GH/CM2	CM		
500.00	1.9002	170.32	19.094	171.28	19.202	1.7798	.19952	.5631	.71883
510.00	1.9854	175.57	19.603	176.57	19.795	1.8300	.20516	.5628	.72925
520.00	1.8713	180.87	20.277	181.89	20.391	1.8805	.21082	.5624	.73937
530.00	1.8577	186.20	20.875	187.26	20.993	1.9312	.21650	.5620	.74919
540.00	1.8446	191.58	21.477	192.66	21.598	1.9822	.22222	.5616	.75871
550.00	1.8321	196.99	22.084	198.10	22.208	2.0334	.22796	.5612	.76794
560.00	1.8201	202.43	22.694	203.57	22.822	2.0848	.23372	.5609	.77687
570.00	1.8085	207.91	23.309	209.09	23.440	2.1365	.23951	.5605	.78552
580.00	1.7974	213.43	23.927	214.63	24.062	2.1893	.24533	.5601	.79389
590.00	1.7867	218.98	24.549	220.21	24.687	2.2404	.25116	.5597	.80199
600.00	1.7763	224.56	25.175	225.83	25.317	2.2926	.25702	.5594	.80981
620.00	1.7568	235.82	26.438	237.15	26.536	2.3977	.26880	.5586	.82468
640.00	1.7387	247.20	27.714	248.59	27.869	2.5034	.28065	.5579	.83854
660.00	1.7218	258.70	29.002	260.15	29.165	2.6099	.29258	.5572	.85144
680.00	1.7060	270.31	30.304	271.82	30.473	2.7169	.30459	.5564	.86343
700.00	1.6913	282.62	31.617	283.60	31.793	2.8246	.31666	.5557	.87456
720.00	1.6775	293.83	32.941	295.47	33.124	2.9328	.32879	.5549	.88482
740.00	1.6646	305.74	34.275	307.44	34.466	3.0415	.34098	.5542	.89442
760.00	1.6526	317.73	35.620	319.50	35.818	3.1508	.35323	.5535	.90325
780.00	1.6412	329.81	36.974	331.64	37.180	3.2605	.36553	.5527	.91140
800.00	1.6306	341.97	38.338	343.87	38.550	3.3707	.37788	.5520	.91992
820.00	1.6206	354.21	39.710	356.17	39.930	3.4813	.39028	.5512	.92585
840.00	1.6112	366.52	41.090	368.55	41.318	3.5923	.40273	.5505	.93223
860.00	1.6023	378.91	42.479	381.00	42.715	3.7037	.41522	.5497	.93810
880.00	1.5940	391.36	43.875	393.52	44.117	3.8155	.42775	.5489	.94350
900.00	1.5861	403.88	45.278	406.11	45.528	3.9276	.44032	.5482	.94845
920.00	1.5786	416.47	46.689	418.76	46.946	4.0401	.45292	.5473	.95299
940.00	1.5716	429.11	48.107	431.47	48.371	4.1529	.46557	.5465	.95716
960.00	1.5650	441.83	49.533	444.25	49.804	4.2660	.47825	.5454	.96097
1000.00	1.5528	467.57	52.418	470.12	52.704	4.4930	.50370	.5429	.96765

THE ELECTRON DENSITY OF COPPER IS 2.750E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.074 BEV, AND THE MINIMUM ENERGY LOSS IS 1.4500 MEV/GM/CM2

FLUORINE

ELEMENT F  
ATOMIC NUMBER 9  
ATOMIC WEIGHT 18.998  
ADJUSTED IONIZATION POTENTIAL 120.7

DENSITY = 1.6952 MG/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS KEV/CM	PROTON RANGE MG/CM <sup>2</sup>	PROTON PATH LENGTH MG/CM <sup>2</sup>	PROTON PATH LENGTH METER	PATH LENGTH STRAGGLING MG/CM <sup>2</sup>	PATH LENGTH STRAGGLING METER	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
1.0	599.65	1016.5	20665	.00122	.20871	.00123	.00746	.9853
1.5	536.17	908.89	29464	.00174	.29684	.00175	.00939	.7416
2.0	481.58	816.35	39260	.00232	.39520	.00233	.01144	.6339
3.0	395.92	671.14	62146	.00367	.62479	.00369	.01608	.5325
4.0	336.41	570.27	89528	.00528	.89962	.00531	.02176	.4815
5.0	296.75	503.04	12114	.00715	1.2169	.00718	.02751	.4496
6.0	270.68	458.84	15657	.00922	1.5704	.00926	.03583	.4271
7.0	251.90	427.01	19457	.01148	1.9537	.01153	.04335	.4099
8.0	234.14	396.90	23559	.01390	2.3652	.01395	.05109	.3957
9.0	213.37	361.70	28017	.01653	2.8125	.01659	.05950	.3835
1.00	192.59	326.47	32932	.01943	3.3055	.01950	.06909	.3728
1.20	169.91	288.02	43978	.02594	4.4135	.02604	.09070	.3557
1.40	152.78	258.98	56375	.03326	5.6569	.03337	.11404	.3428
1.60	139.22	235.99	70071	.04134	7.0305	.04147	.13903	.3326
1.80	128.15	217.23	85023	.05016	8.5300	.05032	.16561	.3242
2.00	118.91	204.57	10119	.05969	10.151	.05988	.19377	.3172
2.20	111.00	186.30	11855	.06993	11.892	.07015	.22344	.3111
2.40	104.34	176.88	13709	.08087	13.751	.08112	.25461	.3058
2.60	98.479	166.94	15678	.09249	15.725	.09277	.28723	.3011
2.80	93.321	158.19	17760	.10477	17.812	.10508	.32127	.2970
3.00	88.742	150.43	19952	.11770	20.011	.11805	.35669	.2932
3.20	84.646	143.49	22254	.13120	22.319	.13166	.39349	.2899
3.40	80.957	137.23	24665	.14550	24.736	.14592	.43163	.2867
3.60	77.613	131.57	27183	.16036	27.260	.16081	.47110	.2838
3.80	74.567	126.40	29806	.17583	29.890	.17632	.51107	.2812
4.00	71.778	121.67	32533	.19192	32.624	.19245	.55353	.2787
4.20	69.213	117.33	35364	.20862	35.462	.20920	.59727	.2764
4.40	66.846	113.31	38297	.22592	38.403	.22654	.64188	.2743
4.60	64.654	109.60	41332	.24383	41.445	.24449	.68773	.2723
4.80	62.616	106.14	44469	.26233	44.589	.26304	.73482	.2704
3.00	88.742	150.43	19952	.11770	20.011	.11805	.35669	.2932
3.20	84.646	143.49	22254	.13120	22.319	.13166	.39349	.2899
3.40	80.957	137.23	24665	.14550	24.736	.14592	.43163	.2867
3.60	77.613	131.57	27183	.16036	27.260	.16081	.47110	.2838
3.80	74.567	126.40	29806	.17583	29.890	.17632	.51107	.2812
4.00	71.778	121.67	32533	.19192	32.624	.19245	.55353	.2787
4.20	69.213	117.33	35364	.20862	35.462	.20920	.59727	.2764
4.40	66.846	113.31	38297	.22592	38.403	.22654	.64188	.2743
4.60	64.654	109.60	41332	.24383	41.445	.24449	.68773	.2723
4.80	62.616	106.14	44469	.26233	44.589	.26304	.73482	.2704

FLUORINE

PRCTON ENERGY MEV	ENERGY LOSS KEV/GH	PROTON RANGE GH/CH2	PROTON PATH LENGTH GH/CH2	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	60.717	102.92	0.4770	0.4770	0.0078	0.0039
5.50	56.486	95.753	0.5623	0.5623	0.0091	0.0050
6.00	52.862	89.609	0.6536	0.6536	0.0104	0.0062
6.50	49.718	84.280	0.7510	0.7510	0.0118	0.0076
7.00	46.962	79.508	0.8564	0.8564	0.0133	0.0092
7.50	44.525	75.476	0.9634	0.9634	0.0149	0.0283
8.00	42.352	71.793	1.0783	1.0783	0.0165	0.0507
8.50	40.402	68.487	1.1989	1.1989	0.0182	0.0732
9.00	38.640	65.501	1.3252	1.3252	0.0199	0.0956
9.50	37.008	62.733	1.4571	1.4571	0.0218	0.1181
10.00	35.554	60.269	1.5947	1.5947	0.0236	0.1405
11.00	32.994	55.931	1.8909	1.8909	0.0276	0.1955
12.00	30.811	52.229	2.2046	2.2046	0.0319	0.2305
13.00	28.924	49.030	2.5339	2.5339	0.0363	0.2757
14.00	27.276	46.237	2.8961	2.8961	0.0411	0.3209
15.00	25.823	43.775	3.2730	3.2730	0.0460	0.3662
16.00	24.533	41.586	3.6704	3.6704	0.0512	0.4117
17.00	23.377	39.628	4.0881	4.0881	0.0566	0.4572
18.00	22.337	37.854	4.5259	4.5259	0.0623	0.5029
19.00	21.395	36.267	4.9835	4.9835	0.0682	0.5487
20.00	20.537	34.813	5.4606	5.4606	0.0743	0.5946
22.00	19.032	32.262	6.4731	6.4731	0.0871	0.6867
24.00	17.755	30.097	7.5618	7.5618	0.1009	0.7792
26.00	16.655	28.233	8.7256	8.7256	0.1154	0.8358
28.00	15.698	26.611	9.9631	9.9631	0.1308	0.8554
30.00	14.858	25.186	1.1273	1.1273	0.1469	0.8758
32.00	14.113	23.924	1.2655	1.2655	0.1638	0.8968
34.00	13.448	22.796	1.4107	1.4107	0.1815	0.9186
36.00	12.851	21.784	1.5629	1.5629	0.2000	0.9409
38.00	12.311	20.869	1.7220	1.7220	0.2191	0.9637
40.00	11.820	20.037	1.8878	1.8878	0.2390	0.9871
45.00	10.770	18.257	2.3315	2.3315	0.2918	1.0773
50.00	9.9137	16.805	2.8159	2.8159	0.3489	1.1096
55.00	9.2016	15.598	3.3399	3.3399	0.4101	1.1743
60.00	8.5996	14.578	3.9024	3.9024	0.4752	1.2419
65.00	8.0836	13.703	4.5024	4.5024	0.5440	1.3171
70.00	7.6361	12.944	5.1391	5.1391	0.6166	1.3945
75.00	7.2443	12.280	5.8117	5.8117	0.6927	1.4589
80.00	6.8982	11.693	6.5193	6.5193	0.7723	1.5349
90.00	6.3141	10.703	8.0365	8.0365	0.9413	1.6905

FLUORINE

PROTON ENERGY MEV	ENERGY LOSS KEV/CH	PROTON RANGE		PATH LENGTH GH/CH2		PROTON PATH LENGTH GH/CH2		PATH LENGTH STRAGGLING GH/CH2		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GH/CH2	METER	GH/CH2	METER	GH/CH2	METER	GH/CH2	METER		
100.00	5.8398	9.6659	57.021	9.6850	57.133	11.228	5.6238	1.159	1.568	.18494	
110.00	5.4468	11.437	67.470	11.460	67.602	13.162	7.7648	1.149	1.558	.20117	
120.00	5.1157	13.329	78.632	13.355	78.785	15.209	8.9719	1.139	1.550	.21781	
130.00	4.8329	15.338	90.480	15.368	90.656	17.361	1.0242	1.130	1.542	.23473	
140.00	4.5885	17.458	102.99	17.492	103.19	19.614	1.1571	1.121	1.535	.25182	
150.00	4.3750	19.687	116.14	19.725	116.36	21.963	1.2956	1.113	1.529	.26899	
160.00	4.1871	22.020	129.90	22.062	130.15	24.403	1.4396	1.106	1.524	.28624	
170.00	4.0203	24.453	144.26	24.500	144.53	26.930	1.5886	1.099	1.519	.30360	
180.00	3.8712	26.984	159.19	27.036	159.49	29.539	1.7426	1.093	1.514	.32100	
190.00	3.7373	29.609	174.67	29.666	175.00	32.227	1.9011	1.086	1.510	.33837	
200.00	3.6163	32.325	190.69	32.386	191.05	34.990	2.0641	1.080	1.506	.35567	
210.00	3.5064	35.128	207.23	35.195	207.62	37.826	2.2314	1.075	1.502	.37289	
220.00	3.4062	38.017	224.27	38.089	224.70	40.730	2.4027	1.069	1.498	.39004	
230.00	3.3145	40.988	241.80	41.066	242.26	43.699	2.5779	1.064	1.495	.40707	
240.00	3.2303	44.039	259.79	44.123	260.29	46.732	2.7566	1.059	1.492	.42395	
250.00	3.1526	47.167	278.25	47.257	278.78	49.825	2.9392	1.054	1.489	.44064	
260.00	3.0808	50.371	297.15	50.466	297.71	52.975	3.1251	1.050	1.486	.45717	
270.00	3.0142	53.647	316.47	53.748	317.07	56.181	3.3142	1.045	1.483	.47353	
280.00	2.9523	56.993	336.21	57.100	336.84	59.440	3.5065	1.041	1.480	.48972	
290.00	2.8947	60.408	356.36	60.521	357.03	62.750	3.7017	1.037	1.478	.50569	
300.00	2.8408	63.889	376.89	64.009	377.60	66.109	3.8999	1.033	1.475	.52144	
310.00	2.7905	67.434	397.81	67.561	398.55	69.515	4.1000	1.029	1.473	.53696	
320.00	2.7432	71.042	419.09	71.175	419.88	72.967	4.3044	1.025	1.471	.55226	
330.00	2.6989	74.711	440.73	74.851	441.56	76.461	4.5106	1.022	1.468	.56731	
340.00	2.6571	78.439	462.72	78.585	463.59	79.998	4.7192	1.018	1.466	.58210	
350.00	2.6178	82.224	485.05	82.377	485.96	83.575	4.9302	1.015	1.464	.59662	
360.00	2.5806	86.064	507.71	86.225	508.66	87.191	5.1435	1.011	1.462	.61090	
370.00	2.5455	89.959	530.69	90.127	531.67	90.844	5.3590	1.008	1.460	.62495	
380.00	2.5123	93.907	553.97	94.081	555.00	94.533	5.5766	1.005	1.458	.63875	
390.00	2.4808	97.905	577.56	98.087	578.63	98.256	5.7963	1.002	1.456	.65233	
400.00	2.4513	101.95	601.44	102.14	602.56	1.0201	6.0100	.9987	1.454	.66563	
410.00	2.4226	106.05	625.61	106.25	626.77	1.0580	6.2415	.9953	1.452	.67861	
420.00	2.3956	110.19	650.05	110.40	651.26	1.0962	6.4669	.9930	1.450	.69122	
430.00	2.3700	114.38	674.77	114.59	676.02	1.1347	6.6940	.9902	1.448	.70345	
440.00	2.3455	118.62	699.74	118.84	701.04	1.1735	6.9229	.9875	1.446	.71531	
450.00	2.3222	122.89	724.98	123.12	726.31	1.2126	7.1534	.9849	1.444	.72680	
460.00	2.2999	127.21	750.46	127.45	751.84	1.2520	7.3855	.9823	1.442	.73792	
470.00	2.2786	131.57	776.10	131.82	777.61	1.2916	7.6192	.9798	1.440	.74838	
480.00	2.2583	135.97	802.14	136.23	803.62	1.3314	7.8543	.9774	1.439	.75909	
490.00	2.2388	140.41	828.33	140.67	829.85	1.3715	8.0909	.9750	1.437	.76914	

FLUORINE

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	HEV/ GM/CM2	KEV/CM	GM/CM2	METER	GM/CM2	METER	GM/CM2	METER PERCENT		
500.00	2.2202	3.7636	144.89	854.74	145.16	856.31	1.4119	8.3289 .9727	.1835	.77884
510.00	2.2024	3.7333	149.41	881.37	149.68	882.99	1.4525	8.5683 .9704	.1833	.78828
520.00	2.1852	3.7043	153.96	908.22	154.24	909.88	1.4933	8.8090 .9681	.1831	.79723
530.00	2.1688	3.6765	158.54	935.27	158.83	936.98	1.5343	9.0509 .9660	.1830	.80593
540.00	2.1530	3.6497	163.16	962.52	163.46	964.28	1.5755	9.2941 .9638	.1828	.81431
550.00	2.1379	3.6240	167.81	989.97	168.12	991.78	1.6169	9.5384 .9618	.1825	.82238
560.00	2.1233	3.5993	172.50	1017.6	172.82	1019.5	1.6585	9.7840 .9597	.1824	.83015
570.00	2.1093	3.5756	177.22	1045.4	177.54	1047.3	1.7003	10.031 .9577	.1823	.83762
580.00	2.0958	3.5527	181.96	1073.4	182.30	1075.4	1.7423	10.278 .9559	.1821	.84450
590.00	2.0829	3.5307	186.74	1101.6	187.08	1103.6	1.7845	10.527 .9539	.1819	.85169
600.00	2.0704	3.5096	191.55	1130.0	191.90	1132.0	1.8269	10.777 .9520	.1818	.85832
620.00	2.0467	3.4694	201.25	1187.2	201.62	1189.4	1.9121	11.280 .9484	.1814	.87079
640.00	2.0247	3.4321	211.06	1245.1	211.44	1247.3	1.9979	11.786 .9449	.1811	.88226
660.00	2.0042	3.3974	220.97	1303.5	221.37	1305.9	2.0843	12.296 .9416	.1807	.89280
680.00	1.9850	3.3649	230.98	1362.6	231.40	1365.1	2.1713	12.809 .9384	.1804	.90247
700.00	1.9671	3.3346	241.08	1422.2	241.52	1424.8	2.2589	13.326 .9353	.1800	.91133
720.00	1.9504	3.3062	251.28	1482.3	251.73	1485.0	2.3469	13.845 .9323	.1797	.91945
740.00	1.9347	3.2795	261.56	1543.0	262.03	1545.7	2.4355	14.367 .9295	.1794	.92686
760.00	1.9199	3.2546	271.92	1604.1	272.41	1607.0	2.5245	14.892 .9267	.1790	.93364
780.00	1.9061	3.2311	282.36	1665.7	282.86	1668.6	2.6139	15.420 .9241	.1787	.93981
800.00	1.8931	3.2091	292.87	1727.7	293.39	1730.8	2.7038	15.950 .9216	.1783	.94545
820.00	1.8800	3.1883	303.45	1790.1	303.99	1793.3	2.7941	16.483 .9191	.1780	.95058
840.00	1.8693	3.1687	314.10	1852.9	314.66	1856.2	2.8847	17.018 .9168	.1777	.95524
860.00	1.8584	3.1503	324.81	1916.1	325.39	1919.5	2.9757	17.554 .9145	.1773	.95949
880.00	1.8482	3.1329	335.59	1979.7	336.19	1983.2	3.0671	18.093 .9123	.1770	.96334
900.00	1.8385	3.1165	346.43	2043.6	347.04	2047.3	3.1588	18.634 .9102	.1767	.96684
920.00	1.8293	3.1009	357.32	2107.9	357.95	2111.6	3.2508	19.177 .9082	.1763	.97002
940.00	1.8206	3.0863	368.28	2172.5	368.93	2176.8	3.3432	19.722 .9062	.1759	.97290
960.00	1.8124	3.0724	379.29	2237.5	379.96	2241.4	3.4358	20.268 .9043	.1755	.97551
1000.00	1.7973	3.0468	401.56	2368.9	402.27	2373.0	3.6219	21.366 .9004	.1745	.98005

THE ELECTRON DENSITY OF FLUORINE IS 2.854E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.226 MEV, AND THE MINIMUM ENERGY LOSS IS 1.6697 MEV/GM/CM2

## GERMANIUM

ATOMIC NUMBER 32  
ELEMENT GE  
ATOMS/MOLECULE 1  
ATOMIC WEIGHT 72.590  
ADJUSTED IONIZATION POTENTIAL 350.0

DENSITY = 5.3600 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE MG/CM <sup>2</sup>	PROTON PATH LENGTH		MG/CM <sup>2</sup>	PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
			MG/CM <sup>2</sup>	MM		MM	PERCENT		
.10	237.56	1273.3	.55850	.00104	.57358	.00107	.02560	2.629	0.
.15	228.14	1222.8	.77183	.00144	.78834	.00147	.03285	2.095	0.
.20	217.63	1166.5	.99330	.00185	1.0127	.00189	.03947	1.917	0.
.30	195.69	1048.9	1.4704	.00274	1.4971	.00279	.05216	1.785	0.
.40	175.49	940.63	2.0020	.00374	2.0370	.00380	.06526	1.717	0.
.50	159.12	852.88	2.5923	.00484	2.6361	.00492	.07929	1.664	0.
.60	146.05	782.83	3.2387	.00604	3.2919	.00614	.09425	1.617	0.
.70	138.06	740.00	3.9326	.00734	3.9955	.00745	.11040	1.576	0.
.80	129.32	693.16	4.6704	.00871	4.7433	.00885	.12753	1.537	0.
.90	119.51	640.55	5.4642	.01019	5.5475	.01035	.14629	1.501	0.
1.00	107.69	597.92	6.3264	.01180	6.4207	.01198	.16738	1.468	0.
1.20	96.611	533.91	8.2183	.01533	8.3359	.01555	.21332	1.412	0.
1.40	91.436	490.10	10.291	.01920	10.434	.01947	.26138	1.365	0.
1.60	84.693	453.95	12.541	.02340	12.709	.02371	.31163	1.326	0.
1.80	79.037	423.64	14.961	.02791	15.157	.02828	.36406	1.291	0.
2.00	74.200	397.71	17.545	.03273	17.769	.03315	.41862	1.261	0.
2.20	69.978	375.08	20.291	.03786	20.545	.03833	.47533	1.234	0.
2.40	66.342	355.59	23.199	.04328	23.483	.04381	.53415	1.210	0.
2.60	63.113	338.29	26.259	.04890	26.574	.04958	.59496	1.188	0.
2.80	60.289	323.15	29.469	.05498	29.818	.05563	.65761	1.169	0.
3.00	57.744	309.51	32.826	.06124	33.208	.06196	.72205	1.151	0.
3.20	55.435	297.13	36.358	.06778	36.745	.06855	.78828	1.134	0.
3.40	53.334	285.87	39.972	.07457	40.424	.07542	.85628	1.119	0.
3.60	51.425	275.64	43.758	.08164	44.246	.08255	.92603	1.105	0.
3.80	49.652	266.13	47.676	.08895	48.202	.08993	.99752	1.092	0.
4.00	48.030	257.44	51.725	.09652	52.300	.09757	1.0707	1.079	0.
4.20	46.527	249.38	55.928	.10434	56.531	.10547	1.1455	1.068	0.
4.40	45.129	241.89	60.251	.11241	60.895	.11361	1.2220	1.057	.00001
4.60	43.824	234.89	64.710	.12073	65.394	.12200	1.3002	1.046	.00001
4.80	42.602	228.35	69.298	.12929	70.024	.13064	1.3800	1.037	.00001

## GERMANIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH GM/CM2 CM		PATH LENGTH STRAGGLING GM/CM2 CM		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
5.00	41.456	.07401	.01381	.07478	.01395	.00146	.00027	1.954	.00001
5.50	38.876	.08037	.01611	.08724	.01628	.00167	.00031	1.917	.00002
6.00	36.635	.09951	.01856	.10050	.01875	.00190	.00035	1.887	.00004
6.50	34.666	.11342	.02116	.11454	.02137	.00213	.00040	1.861	.00006
7.00	32.922	.12810	.02390	.12934	.02413	.00238	.00044	1.838	.00008
7.50	31.366	.14354	.02678	.14491	.02704	.00263	.00049	1.818	.00011
8.00	29.959	.15972	.02980	.16122	.03008	.00290	.00054	1.799	.00015
8.50	28.706	.17663	.03295	.17827	.03326	.00318	.00059	1.783	.00020
9.00	27.560	.19427	.03625	.19606	.03658	.00346	.00065	1.767	.00025
9.50	26.514	.21262	.03967	.21455	.04033	.00376	.00070	1.753	.00031
10.00	25.552	.23169	.04322	.23377	.04361	.00407	.00076	1.740	.00037
11.00	23.848	.27190	.05073	.27430	.05119	.00471	.00088	1.715	.00052
12.00	22.377	.31488	.05875	.31782	.05926	.00538	.00100	1.694	.00070
13.00	21.104	.36057	.06727	.36366	.06785	.00609	.00114	1.674	.00091
14.00	19.979	.40982	.07629	.41238	.07694	.00683	.00127	1.656	.00114
15.00	18.994	.45990	.08580	.46374	.08652	.00760	.00142	1.640	.00140
16.00	18.114	.51343	.09579	.51768	.09658	.00841	.00157	1.625	.00342
17.00	17.321	.56848	.10625	.57414	.10712	.00923	.00173	1.610	.00572
18.00	16.603	.62802	.11717	.63311	.11812	.01011	.00189	1.597	.00804
19.00	15.949	.68906	.12856	.69460	.12959	.01101	.00205	1.585	.01037
20.00	15.360	.75248	.14039	.75848	.14151	.01193	.00223	1.573	.01272
22.00	14.302	.88657	.16540	.89354	.16671	.01387	.00259	1.552	.01748
24.00	13.396	1.0301	.19219	1.0381	.19368	.01592	.00297	1.533	.02331
26.00	12.612	1.1830	.22071	1.1921	.22241	.01807	.00337	1.516	.02553
28.00	11.927	1.3450	.25093	1.3552	.25284	.02034	.00379	1.501	.02707
30.00	11.321	1.5160	.28283	1.5274	.28496	.02271	.00424	1.487	.02867
32.00	10.782	1.6959	.31639	1.7085	.31876	.02516	.00470	1.474	.03034
34.00	10.299	1.8844	.35157	1.8984	.35477	.02776	.00518	1.462	.03207
36.00	9.8637	2.0815	.38834	2.0968	.39163	.03043	.00568	1.451	.03386
38.00	9.4690	2.2871	.42670	2.3039	.42983	.03320	.00619	1.441	.03570
40.00	9.1093	2.5011	.46662	2.5193	.47001	.03606	.00673	1.431	.03759
45.00	8.3354	3.0717	.57308	3.0936	.57719	.04362	.00814	1.410	.04252
50.00	7.7008	3.6922	.68885	3.7185	.69374	.05173	.00965	1.391	.04771
55.00	7.1703	4.3612	.81366	4.3919	.81936	.06033	.01126	1.375	.05316
60.00	6.7195	5.0733	.94725	5.1127	.95386	.06953	.01297	1.360	.05889
65.00	6.3320	5.8992	1.0894	5.8796	1.0969	.07918	.01477	1.347	.06485
70.00	5.9948	6.6458	1.2399	6.6916	1.2484	.08930	.01664	1.335	.07105
75.00	5.6986	7.4961	1.3985	7.5474	1.4081	.09988	.01863	1.323	.07744
80.00	5.4362	8.3890	1.5651	8.4461	1.5758	.11090	.02069	1.313	.08401
90.00	4.9917	10.299	1.9214	10.368	1.9344	.13422	.02564	1.295	.09760



## GERMANIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CH2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CH2	CM	GM/CH2	CH	GM/CH2	CH		
100.00	4.6293	12.368	2.3074	12.450	2.3228	.15914	.02969	1.278	.11168
110.00	4.3276	14.589	2.7219	14.686	2.7400	.18559	.03463	1.264	.12623
120.00	4.0728	16.958	3.1638	17.070	3.1847	.21348	.03983	1.251	.14124
130.00	3.8547	19.467	3.6319	19.595	3.6558	.24271	.04528	1.239	.15864
140.00	3.6658	22.112	4.1253	22.257	4.1523	.27323	.05098	1.228	.17232
150.00	3.5005	24.986	4.6429	25.049	4.6733	.30496	.05690	1.217	.18821
160.00	3.3546	27.787	5.1841	27.968	5.2179	.33784	.06303	1.206	.20433
170.00	3.2250	30.809	5.7480	31.009	5.7853	.37183	.06937	1.199	.22071
180.00	3.1090	33.948	6.3336	34.168	6.3746	.40685	.07591	1.191	.23730
190.00	3.0046	37.200	6.9404	37.441	6.9852	.44287	.08263	1.183	.25403
200.00	2.9101	40.562	7.5675	40.823	7.6163	.47984	.08952	1.175	.27086
210.00	2.8243	44.029	8.2143	44.312	8.2672	.51771	.09659	1.168	.28776
220.00	2.7460	47.598	8.8802	47.903	8.9372	.55645	.10381	1.162	.30470
230.00	2.6742	51.266	9.5645	51.594	9.6257	.59600	.11119	1.155	.32164
240.00	2.6082	55.028	10.267	55.380	10.332	.63635	.11872	1.149	.33857
250.00	2.5473	58.884	10.986	59.260	11.056	.67745	.12639	1.143	.35537
260.00	2.4910	62.830	11.722	63.231	11.797	.71927	.13419	1.138	.37211
270.00	2.4387	66.863	12.474	67.288	12.554	.76178	.14212	1.132	.38874
280.00	2.3901	70.979	13.242	71.431	13.327	.80495	.15018	1.127	.40524
290.00	2.3449	75.177	14.026	75.655	14.115	.84875	.15835	1.122	.42157
300.00	2.3025	79.455	14.824	79.959	14.918	.89316	.16664	1.117	.43773
310.00	2.2629	83.809	15.636	84.340	15.735	.93816	.17503	1.112	.45371
320.00	2.2258	88.237	16.462	88.796	16.566	.98371	.18353	1.108	.46952
330.00	2.1909	92.738	17.302	93.325	17.411	1.0298	.19213	1.103	.48512
340.00	2.1580	97.309	18.155	97.924	18.269	1.0764	.20082	1.099	.50052
350.00	2.1271	101.95	19.020	102.59	19.140	1.1235	.20961	1.095	.51570
360.00	2.0978	106.65	19.898	107.33	20.023	1.1711	.21848	1.091	.53063
370.00	2.0702	111.42	20.788	112.12	20.919	1.2191	.22744	1.087	.54530
380.00	2.0440	116.25	21.689	116.99	21.826	1.2676	.23649	1.084	.55972
390.00	2.0193	121.15	22.602	121.91	22.744	1.3165	.24561	1.080	.57385
400.00	1.9957	126.10	23.526	126.89	23.673	1.3658	.25481	1.076	.58771
410.00	1.9734	131.11	24.460	131.93	24.614	1.4155	.26408	1.073	.60128
420.00	1.9522	136.17	25.405	137.02	25.564	1.4655	.27342	1.070	.61455
430.00	1.9320	141.29	26.359	142.17	26.525	1.5160	.28283	1.066	.62753
440.00	1.9127	146.46	27.324	147.38	27.495	1.5667	.29231	1.062	.64021
450.00	1.8943	151.68	28.298	152.63	28.476	1.6179	.30184	1.060	.65258
460.00	1.8768	156.95	29.282	157.93	29.465	1.6695	.31144	1.057	.66465
470.00	1.8600	162.27	30.274	163.28	30.464	1.7211	.32110	1.054	.67641
480.00	1.8440	167.64	31.275	168.68	31.471	1.7732	.33081	1.051	.68787
490.00	1.8287	173.05	32.285	174.13	32.487	1.8255	.34058	1.048	.69902

GERMANIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GH/CH2	PROTON PATH LENGTH GH/CH2	PATH LENGTH STRAGGLING GH/CH2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.8141	9.7233	178.51	33.303	1.8782	.70987
510.00	1.8000	9.6480	184.01	34.330	1.9311	.72042
520.00	1.7865	9.5758	189.55	35.364	1.9843	.73067
530.00	1.7736	9.5066	195.13	36.405	2.0377	.74062
540.00	1.7612	9.4401	200.76	37.455	2.0914	.75026
550.00	1.7493	9.3763	206.42	38.511	2.1453	.75965
560.00	1.7379	9.3149	212.12	39.575	2.1995	.76873
570.00	1.7269	9.2559	217.06	40.645	2.2538	.77754
580.00	1.7163	9.1992	223.63	41.722	2.3084	.78606
590.00	1.7061	9.1446	229.44	42.806	2.3632	.79432
600.00	1.6963	9.0920	235.28	43.896	2.4183	.80230
620.00	1.6777	8.9925	247.07	46.380	2.5289	.81750
640.00	1.6605	8.9000	258.98	48.317	2.6402	.83169
660.00	1.6444	8.8139	271.01	50.874	2.7522	.84492
680.00	1.6294	8.7336	283.16	52.828	2.8649	.85725
700.00	1.6154	8.6586	295.41	55.114	2.9783	.86870
720.00	1.6023	8.5885	307.77	57.420	3.0922	.87934
740.00	1.5901	8.5228	320.23	59.744	3.2066	.88922
760.00	1.5786	8.4613	332.78	62.085	3.3216	.89834
780.00	1.5678	8.4036	345.42	64.443	3.4370	.90679
800.00	1.5577	8.3494	358.14	66.817	3.5530	.91460
820.00	1.5482	8.2985	370.94	69.206	3.6694	.92181
840.00	1.5393	8.2506	383.83	71.609	3.7862	.92846
860.00	1.5309	8.2055	396.78	74.026	3.9034	.93458
880.00	1.5229	8.1630	409.81	76.457	4.0210	.94021
900.00	1.5155	8.1229	422.90	78.900	4.1389	.94540
920.00	1.5084	8.0851	436.07	81.356	4.2572	.95016
940.00	1.5018	8.0495	449.30	83.824	4.3759	.95453
960.00	1.4955	8.0158	462.60	86.307	4.4948	.95854
1000.00	1.4839	7.9539	489.52	91.878	4.7336	.96556

THE ELECTRON DENSITY OF GERMANIUM IS 2.656E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.059 BEV, AND THE MINIMUM ENERGY LOSS IS 1.3947 MEV/GH/CH2

# GOLD

ATOMIC ELEMENT NUMBER 79  
 ATOMS/MOLECULE 1  
 ATOMIC WEIGHT 196.97  
 ADJUSTED IONIZATION POTENTIAL 780.0

DENSITY = 19.320 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE MG/CH2	PROTON PATH LENGTH MM	PROTON PATH LENGTH HG/CH2	PATH LENGTH STRAGGLING MM	PATH LENGTH STRAGGLING HG/CH2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	104.91	1.2502	.0065	1.3200	.0003	.06726	5.290	0.
.15	116.33	1.6945	.0088	1.7724	.0004	.08585	4.283	0.
.20	118.68	2.1099	.0109	2.1978	.0005	.09862	3.999	0.
.30	110.35	2.9488	.0153	3.0668	.0006	.12470	3.850	0.
.40	98.012	3.8748	.0201	4.0282	.0008	.15496	3.847	0.
.50	88.077	4.9131	.0254	5.1063	.0010	.18980	3.782	0.
.60	80.891	6.0560	.0313	6.2924	.0012	.22771	3.757	0.
.70	74.994	7.2933	.0378	7.5760	.0014	.26764	3.731	0.
.80	70.003	8.6249	.0446	8.9564	.0016	.30955	3.702	0.
.90	66.803	10.035	.0519	10.418	.0018	.35236	3.672	0.
1.00	63.601	11.517	.0596	11.953	.0020	.39550	3.641	0.
1.20	59.084	14.671	.0759	15.216	.0025	.48238	3.576	0.
1.40	55.155	18.063	.0935	18.721	.0030	.57145	3.512	0.
1.60	52.023	21.663	.1122	22.458	.0034	.66566	3.449	0.
1.80	49.237	25.520	.1321	26.415	.0040	.76394	3.388	0.
2.00	46.761	29.563	.1536	30.582	.0045	.86589	3.330	0.
2.20	44.546	33.863	.1731	34.968	.0050	.97125	3.274	0.
2.40	42.567	38.287	.1982	39.562	.0056	1.0799	3.222	0.
2.60	40.780	42.955	.2223	44.362	.0062	1.1916	3.172	0.
2.80	39.158	47.826	.2475	49.370	.0068	1.3063	3.126	0.
3.00	37.679	52.895	.2738	54.578	.0074	1.4240	3.082	0.
3.20	36.324	58.159	.3010	59.983	.0080	1.5446	3.041	0.
3.40	35.080	63.616	.3293	65.585	.0086	1.6679	3.002	0.
3.60	33.922	69.265	.3585	71.386	.0093	1.7940	2.966	0.
3.80	32.863	75.109	.3888	77.377	.0100	1.9230	2.931	0.
4.00	31.882	81.134	.4200	83.556	.0106	2.0545	2.899	0.
4.20	30.968	87.335	.4521	89.923	.0113	2.1886	2.868	0.
4.40	30.114	93.734	.4852	96.473	.0120	2.3252	2.838	0.
4.60	29.313	100.30	.5192	103.20	.0128	2.4643	2.810	0.
4.80	28.559	107.05	.5541	110.12	.0135	2.6058	2.784	0.

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GH/CH2	MEV/CH	GH/CH2	CM	GH/CH2	CM	GH/CH2	PERCENT		
5.00	27.549	538.05	.11398	.00590	.11721	.00607	.00275	.00014	2.346	0.
5.50	26.234	506.85	.13205	.00684	.13572	.00702	.00312	.00016	2.299	0.
6.00	24.862	480.32	.15119	.00783	.15530	.00804	.00351	.00018	2.258	0.
6.50	23.646	456.85	.17135	.00887	.17593	.00911	.00391	.00020	2.220	0.
7.00	22.563	435.93	.19253	.00997	.19759	.01023	.00432	.00022	2.188	.00031
7.50	21.592	417.15	.21469	.01111	.22025	.01140	.00476	.00025	2.161	.00031
8.00	20.822	402.27	.23776	.01231	.24382	.01262	.00521	.00027	2.135	.00031
8.50	20.010	386.60	.26172	.01355	.26831	.01389	.00567	.00029	2.112	.00002
9.00	19.272	372.33	.28661	.01484	.29374	.01520	.00614	.00032	2.091	.00002
9.50	18.589	359.15	.31249	.01617	.32017	.01657	.00663	.00034	2.071	.00002
10.00	17.973	347.24	.33933	.01756	.34757	.01799	.00714	.00037	2.053	.00002
11.00	16.875	326.02	.39564	.02048	.40506	.02097	.00818	.00042	2.020	.00004
12.00	15.922	307.60	.45538	.02357	.46602	.02412	.00928	.00048	1.991	.00006
13.00	15.091	291.55	.51872	.02685	.53064	.02747	.01042	.00054	1.964	.00010
14.00	14.355	277.34	.58536	.03030	.59861	.03098	.01161	.00060	1.940	.00016
15.00	13.697	264.63	.65530	.03392	.66993	.03468	.01284	.00066	1.917	.00023
16.00	13.108	253.24	.72849	.03771	.74455	.03854	.01412	.00073	1.896	.00033
17.00	12.575	242.94	.80488	.04166	.82241	.04257	.01543	.00080	1.876	.00045
18.00	12.090	233.57	.88459	.04579	.90365	.04677	.01679	.00097	1.858	.00059
19.00	11.647	225.01	.96726	.05006	.98789	.05113	.01818	.00094	1.841	.00076
20.00	11.240	217.16	1.05331	.05451	1.0753	.05566	.01962	.00102	1.824	.00095
22.00	10.519	203.23	1.2337	.06386	1.2593	.06518	.02260	.00117	1.795	.00139
24.00	9.8987	191.24	1.4263	.07382	1.4555	.07533	.02573	.00133	1.769	.00191
26.00	9.3574	180.79	1.6305	.08439	1.6634	.08609	.02900	.00150	1.744	.00287
28.00	8.8822	171.60	1.8460	.09555	1.8828	.09745	.03241	.00168	1.722	.00426
30.00	8.4589	163.43	2.0728	.10729	2.1136	.10940	.03596	.00186	1.702	.00570
32.00	8.1047	156.58	2.3106	.11960	2.3557	.12193	.03964	.00205	1.683	.00720
34.00	7.7648	150.02	2.5587	.13244	2.6081	.13499	.04342	.00225	1.665	.00875
36.00	7.4569	144.07	2.8166	.14579	2.8706	.14858	.04733	.00245	1.649	.01034
38.00	7.1747	138.61	3.0853	.15969	3.1438	.16273	.05135	.00266	1.633	.01199
40.00	6.9194	133.68	3.3647	.17416	3.4281	.17744	.05550	.00287	1.619	.01368
45.00	6.3655	122.98	4.1066	.21256	4.1827	.21650	.06643	.00344	1.588	.01808
50.00	5.9079	114.14	4.9084	.25406	4.9980	.25870	.07812	.00404	1.563	.02272
55.00	5.5223	106.69	5.7703	.29867	5.8744	.30406	.09052	.00469</		

## GOLD

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CH	GM/CM2	CH		
100.00	3.6365	15.939	82498	16.208	83892	.22935	.01188	1.416	.08052
110.00	3.4096	18.732	96958	19.046	98581	.26624	.01378	1.390	.09388
120.00	3.2169	21.706	11235	22.067	11422	.30473	.01577	1.381	.10774
130.00	3.0513	24.850	12862	25.260	13075	.34493	.01785	1.365	.12202
140.00	2.9074	28.156	14573	28.618	14813	.38674	.02002	1.352	.13666
150.00	2.7811	31.619	16366	32.135	16633	.43008	.02226	1.338	.15159
160.00	2.6694	35.230	18235	35.803	18532	.47486	.02458	1.326	.16681
170.00	2.5700	38.990	20181	39.621	20508	.52102	.02697	1.315	.18233
180.00	2.4808	42.890	22200	43.582	22558	.56849	.02942	1.304	.19810
190.00	2.4004	46.925	24288	47.680	24679	.61719	.03195	1.294	.21406
200.00	2.3276	51.091	26445	51.911	26869	.66708	.03453	1.285	.23019
210.00	2.2613	55.384	28666	56.270	29125	.71808	.03717	1.276	.24639
220.00	2.2029	59.792	30948	60.746	31442	.77036	.03986	1.268	.26257
230.00	2.1472	64.324	33294	65.349	33824	.82302	.04260	1.259	.27871
240.00	2.0959	68.970	35699	70.067	36257	.87696	.04539	1.252	.29477
250.00	2.0486	73.712	38153	74.882	38759	.93185	.04823	1.244	.31074
260.00	2.0048	78.575	40670	79.820	41315	.98763	.05112	1.237	.32663
270.00	1.9641	83.538	43239	84.820	43923	1.0443	.05405	1.231	.34246
280.00	1.9263	88.604	45861	89.803	46582	1.1017	.05702	1.224	.35820
290.00	1.0910	93.767	48534	95.246	49299	1.1600	.06004	1.218	.37395
300.00	1.8580	99.024	51295	100.58	52062	1.2189	.06309	1.212	.38936
310.00	1.8271	104.35	54012	105.99	54862	1.2786	.06618	1.206	.40477
320.00	1.7971	109.79	56826	111.51	57718	1.3391	.06931	1.201	.42008
330.00	1.7699	115.32	59688	117.13	60625	1.4002	.07247	1.195	.43530
340.00	1.7442	120.92	62580	122.82	63570	1.4619	.07567	1.190	.45038
350.00	1.7201	126.61	65532	128.59	66558	1.5243	.07890	1.185	.46531
360.00	1.6972	132.37	68515	134.44	69587	1.5872	.08216	1.181	.48007
370.00	1.6756	138.21	71537	140.37	72655	1.6507	.08544	1.178	.49460
380.00	1.6552	144.18	74629	146.43	75794	1.7148	.08876	1.171	.50891
390.00	1.6359	150.17	77727	152.51	78939	1.7793	.09210	1.167	.52297
400.00	1.6175	156.22	80862	158.66	82122	1.8443	.09546	1.162	.53680
410.00	1.6001	162.35	84031	164.88	85340	1.9098	.09885	1.158	.55038
420.00	1.5835	168.54	87235	171.16	88592	1.9757	.10226	1.154	.56372
430.00	1.5677	174.74	90447	177.46	91854	2.0421	.10570	1.151	.57682
440.00	1.5526	181.04	93705	183.85	95161	2.1089	.10915	1.147	.58968
450.00	1.5383	187.41	97003	190.32	98510	2.1760	.11263	1.143	.60228
460.00	1.5246	193.84	100333	196.85	10189	2.2436	.11613	1.140	.61463
470.00	1.5115	200.33	10369	203.43	10530	2.3116	.11965	1.136	.62671
480.00	1.4990	206.87	10708	210.08	10874	2.3799	.12316	1.133	.63854
490.00	1.4870	213.47	11049	216.77	11220	2.4485	.12673	1.130	.65010

## GOLD

PROTON ENERGY MEV	ENERGY LOSS KEV/ GM/CM <sup>2</sup>	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH GM/CM <sup>2</sup>	PATH LENGTH STRAGGLING GM/CM <sup>2</sup>	PATH LENGTH STRAGGLING PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.4756	220.11	223.52	2.5175	1.126	1.525	.66140
510.00	1.4646	226.81	230.32	2.5868	1.123	1.524	.67357
520.00	1.4541	233.53	237.17	2.6564	1.120	1.523	.68321
530.00	1.4440	240.36	244.07	2.7263	1.117	1.522	.69371
540.00	1.4344	247.12	251.02	2.7965	1.114	1.521	.70396
550.00	1.4251	254.09	258.01	2.8669	1.111	1.520	.71394
560.00	1.4162	261.06	265.08	2.9377	1.108	1.519	.72367
570.00	1.4076	268.03	272.17	3.0087	1.105	1.518	.73313
580.00	1.3993	275.05	279.29	3.0799	1.103	1.517	.74234
590.00	1.3914	282.11	286.46	3.1514	1.100	1.517	.75130
600.00	1.3838	289.21	293.66	3.2231	1.098	1.516	.76001
620.00	1.3693	303.52	308.18	3.3572	1.093	1.514	.77669
640.00	1.3559	317.98	322.87	3.5121	1.088	1.513	.79242
660.00	1.3434	332.62	337.72	3.6578	1.083	1.511	.80722
680.00	1.3318	347.48	352.81	3.8043	1.078	1.509	.82113
700.00	1.3210	362.35	367.89	3.9514	1.074	1.507	.83419
720.00	1.3108	377.33	383.10	4.0992	1.070	1.506	.84642
740.00	1.3013	392.43	398.42	4.2476	1.066	1.505	.85787
760.00	1.2925	407.63	413.85	4.3966	1.062	1.503	.86857
780.00	1.2842	422.94	429.39	4.5461	1.059	1.501	.87856
800.00	1.2764	438.34	445.02	4.6961	1.055	1.500	.88788
820.00	1.2691	453.84	460.74	4.8466	1.052	1.498	.89656
840.00	1.2622	469.42	476.55	4.9976	1.049	1.497	.90463
860.00	1.2557	485.09	492.46	5.1489	1.046	1.495	.91214
880.00	1.2497	500.84	508.44	5.3007	1.043	1.494	.91911
900.00	1.2440	516.68	524.50	5.4529	1.040	1.492	.92557
920.00	1.2386	532.58	540.64	5.6054	1.037	1.490	.93156
940.00	1.2335	548.57	556.85	5.7583	1.034	1.488	.93711
960.00	1.2287	564.64	573.16	5.9115	1.031	1.486	.94224
1000.00	1.2200	597.15	606.12	6.2168	1.026	1.479	.95133

THE ELECTRON DENSITY OF GOLD IS 2.416E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.02 SEV, AND THE MINIMUM ENERGY LOSS IS 1.1570 MEV/GM/CM<sup>2</sup>

# HELIUM

ELEMENT  
 HE

ATOMIC  
 NUMBER  
 2

ATOMS/  
 MOLECULE  
 1

ATOMIC  
 WEIGHT  
 4.0026

ADJUSTED  
 IONIZATION  
 POTENTIAL  
 41.70

DENSITY = .17847 MG/CM3

PRCTON ENERGY MEV	ENERGY LOSS GM/CM2 KEV/CM	PROTON RANGE MG/CM2 METER	PROTON PATH LENGTH HG/CM2 METER	PATH LENGTH STRAGGLING MG/CM2 METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	1096.1	11435	.00642	.00289	.3077	0.
.15	954.64	16297	.00913	.00385	.2295	0.
.20	832.61	21898	.01227	.00489	.1927	0.
.30	661.65	35425	.01985	.00734	.1567	0.
.40	554.41	51971	.02912	.01024	.1387	0.
.50	477.81	71417	.04002	.01355	.1277	0.
.60	422.19	93698	.05256	.01727	.1202	0.
.70	374.95	11379	.06664	.02133	.1146	0.
.80	341.01	14674	.08222	.02592	.1103	0.
.90	313.93	17729	.09934	.03079	.1068	0.
1.00	285.03	21074	.11808	.03611	.1040	0.
1.20	248.54	28598	.16024	.04800	.0995	.00001
1.40	221.03	37141	.20831	.06113	.0963	.00032
1.60	199.47	45676	.26178	.07548	.0938	.00084
1.80	182.07	57177	.32037	.09102	.0917	.00007
2.00	167.71	68622	.38450	.10772	.0900	.00011
2.20	155.63	80997	.45384	.12557	.0885	.00016
2.40	145.32	94296	.52836	.14454	.0873	.00023
2.60	136.40	108390	.60795	.16462	.0862	.00031
2.80	128.60	123360	.69253	.18577	.0852	.00040
3.00	121.72	13957	.78206	.20799	.0843	.00050
3.20	115.60	15643	.87650	.23127	.0835	.00169
3.40	110.12	17415	.97573	.25558	.0828	.00492
3.60	105.18	19273	1.0799	.28092	.0821	.00813
3.80	100.70	21215	1.1887	.30727	.0815	.01132
4.00	96.617	23241	1.3023	.33461	.0809	.01448
4.20	92.882	25352	1.4205	.36295	.0804	.01761
4.40	89.449	27545	1.5434	.39227	.0799	.02073
4.60	86.283	29820	1.6709	.42255	.0794	.02382
4.80	83.353	32177	1.8029	.45380	.0790	.02690

HELIUM

PRCTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON LENGTH PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	83.632	0.3462	1.9395	0.0049	0.2723	1.403
5.50	74.608	0.4106	2.3008	0.0057	0.3197	1.388
6.00	69.489	0.4801	2.6899	0.0066	0.3703	1.376
6.50	65.081	0.5544	3.1065	0.0076	0.4242	1.364
7.00	61.243	0.6336	3.5501	0.0086	0.4811	1.354
7.50	57.868	0.7176	4.0206	0.0097	0.5411	1.345
8.00	54.875	0.8063	4.5176	0.0108	0.6041	1.336
8.50	52.202	0.8996	5.0409	0.0120	0.6701	1.328
9.00	49.798	0.9977	5.5902	0.0132	0.7390	1.321
9.50	47.624	1.1003	6.1652	0.0145	0.8109	1.314
10.00	45.648	1.2075	6.7707	0.0158	0.8856	1.308
11.00	42.189	1.4354	8.0429	0.0186	1.0435	1.296
12.00	39.236	1.6811	9.4198	0.0216	1.2125	1.286
13.00	36.738	1.9445	10.895	0.0248	1.3923	1.277
14.00	34.549	2.2251	12.468	0.0283	1.5829	1.269
15.00	32.628	2.5229	14.136	0.0318	1.7839	1.261
16.00	30.927	2.8376	15.900	0.0356	1.9953	1.254
17.00	29.411	3.1691	17.757	0.0396	2.2169	1.248
18.00	28.050	3.5171	19.707	0.0437	2.4484	1.242
19.00	26.820	3.8815	21.749	0.0480	2.6899	1.236
20.00	25.704	4.2623	23.883	0.0525	2.9410	1.231
22.00	23.753	5.0719	28.419	0.0620	3.4721	1.221
24.00	22.103	5.9449	33.310	0.0721	4.0407	1.212
26.00	20.639	6.8801	38.551	0.0829	4.6460	1.204
28.00	19.462	7.8767	44.135	0.0944	5.2872	1.197
30.00	18.387	8.9338	50.058	0.1064	5.9635	1.191
32.00	17.437	1.0051	56.315	0.1191	6.6742	1.184
34.00	16.591	1.1226	62.902	0.1324	7.4188	1.179
36.00	15.832	1.2460	69.814	0.1463	8.1966	1.173
38.00	15.148	1.3751	77.048	0.1607	9.0069	1.168
40.00	14.528	1.5109	84.600	0.1758	9.8494	1.163
45.00	13.202	1.8712	104.84	0.2158	1.2092	1.153
50.00	12.126	2.2665	127.00	0.2592	1.4525	1.143
55.00	11.233	2.6951	151.01	0.3059	1.7140	1.134
60.00	10.480	3.1560	176.83	0.3557	1.9931	1.126
65.00	9.8363	3.6484	204.43	0.4085	2.2892	1.119
70.00	9.2791	4.1718	233.75	0.4643	2.6017	1.112
75.00	8.7921	4.7253	264.76	0.5230	2.9303	1.106
80.00	8.3625	5.3083	297.43	0.5844	3.2743	1.100
90.00	7.6391	6.5604	367.59	0.7151	4.0068	1.089



HELIUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	KEV/CM	GM/CM2	METER	GM/CM2	METER	GM/CM2	METER PERCENT		
100.00	7.0531	1.2588	7.9234	443.96	7.9281	444.23	.08559	4.7960	1.080	.42859
110.00	6.5686	1.1723	9.3929	526.30	9.3986	526.62	.10064	5.6388	1.071	.44956
120.00	6.1611	1.0996	10.965	614.76	10.972	614.76	.11658	6.5323	1.063	.47137
130.00	5.8135	1.0375	12.636	708.44	12.644	708.44	.13339	7.4740	1.055	.49384
140.00	5.5135	.98400	14.402	806.98	14.411	807.46	.15101	8.4614	1.048	.51680
150.00	5.2519	.93730	16.260	911.10	16.270	913.43	.16941	9.4924	1.041	.54006
160.00	5.0217	.89623	18.207	1020.2	18.218	1020.8	.18855	10.565	1.035	.56316
170.00	4.8177	.85981	20.240	1134.1	20.252	1134.7	.20840	11.677	1.029	.58563
180.00	4.6355	.82730	22.355	1252.6	22.368	1253.3	.22892	12.827	1.023	.60740
190.00	4.4719	.79810	24.551	1375.6	24.565	1376.4	.25008	14.012	1.018	.62841
200.00	4.3242	.77174	26.824	1503.0	26.840	1503.9	.27186	15.233	1.013	.64859
210.00	4.1902	.74782	29.173	1634.6	29.190	1635.5	.29422	16.486	1.008	.66737
220.00	4.0680	.72602	31.594	1770.3	31.612	1771.3	.31715	17.771	1.003	.68422
230.00	3.9563	.70608	34.086	1909.9	34.105	1911.0	.34062	19.086	.9987	.69926
240.00	3.8537	.68777	36.646	2053.3	36.667	2054.5	.36461	20.429	.9944	.71257
250.00	3.7591	.67089	39.272	2200.5	39.294	2201.7	.38909	21.801	.9902	.72424
260.00	3.6717	.65529	41.962	2351.2	41.986	2352.6	.41404	23.200	.9861	.73488
270.00	3.5907	.64084	44.715	2505.5	44.741	2506.9	.43946	24.624	.9822	.74566
280.00	3.5155	.62741	47.529	2663.1	47.556	2664.6	.46531	26.072	.9785	.75478
290.00	3.4454	.61489	50.401	2824.0	50.429	2825.6	.49158	27.544	.9748	.76405
300.00	3.3799	.60321	53.330	2988.2	53.360	2989.9	.51826	29.039	.9713	.77287
310.00	3.3187	.59228	56.314	3155.4	56.346	3157.2	.54533	30.556	.9678	.78187
320.00	3.2613	.58204	59.353	3325.6	59.386	3327.5	.57278	32.094	.9645	.79162
330.00	3.2074	.57242	62.443	3498.8	62.478	3500.3	.60059	33.652	.9613	.80201
340.00	3.1566	.56336	65.584	3674.8	65.621	3676.9	.62874	35.229	.9581	.81292
350.00	3.1088	.55484	68.775	3853.6	68.814	3855.8	.65723	36.826	.9551	.82423
360.00	3.0637	.54679	72.014	4035.1	72.054	4037.3	.68604	38.440	.9521	.83556
370.00	3.0211	.53918	75.299	4219.1	75.341	4221.5	.71517	40.072	.9492	.84660
380.00	2.9808	.53198	78.630	4405.8	78.674	4408.2	.74460	41.721	.9464	.85731
390.00	2.9425	.52516	82.005	4594.9	82.050	4597.4	.77431	43.386	.9437	.86767
400.00	2.9063	.51868	85.423	4786.4	85.470	4789.0	.80431	45.067	.9410	.87763
410.00	2.8718	.51253	88.882	4980.2	88.932	4983.0	.83458	46.763	.9385	.88705
420.00	2.8391	.50669	92.383	5176.4	92.434	5179.2	.86511	48.474	.9359	.89581
430.00	2.8079	.50112	95.923	5374.7	95.976	5377.7	.89590	50.199	.9335	.90395
440.00	2.7782	.49582	99.502	5575.3	99.556	5578.3	.92693	51.937	.9311	.91150
450.00	2.7498	.49076	103.12	5777.9	103.17	5781.1	.95819	53.689	.9287	.91851
460.00	2.7228	.48593	106.77	5982.6	106.83	5985.8	.98969	55.454	.9264	.92500
470.00	2.6969	.48132	110.46	6189.2	110.52	6192.6	1.0214	57.231	.9242	.93101
480.00	2.6722	.47691	114.18	6397.8	114.24	6401.3	1.0533	59.020	.9220	.93657
490.00	2.6486	.47269	117.94	6608.4	118.00	6612.0	1.0855	60.821	.9199	.94171

# HELIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.6259	121.73	121.80	1.1178	.0546	.94645
510.00	2.6042	125.55	125.62	1.1504	.0545	.95082
520.00	2.5834	129.40	129.48	1.1831	.0544	.95486
530.00	2.5634	133.29	133.36	1.2160	.0543	.95858
540.00	2.5442	137.20	137.28	1.2491	.0543	.96200
550.00	2.5258	141.15	141.22	1.2823	.0542	.96516
560.00	2.5081	145.12	145.20	1.3158	.0541	.96806
570.00	2.4910	149.12	149.20	1.3494	.0540	.97072
580.00	2.4746	153.14	153.22	1.3831	.0539	.97317
590.00	2.4588	157.19	157.28	1.4170	.0539	.97543
600.00	2.4436	161.27	161.36	1.4511	.0538	.97749
620.00	2.4148	169.50	169.59	1.5197	.0536	.98113
640.00	2.3879	177.83	177.92	1.5888	.0535	.98419
660.00	2.3629	186.24	186.34	1.6584	.0534	.98676
680.00	2.3395	194.74	194.85	1.7285	.0532	.98892
700.00	2.3177	203.33	203.44	1.7991	.0531	.99073
720.00	2.2972	211.99	212.11	1.8702	.0529	.99224
740.00	2.2780	220.73	220.85	1.9417	.0528	.99351
760.00	2.2595	229.54	229.66	2.0136	.0527	.99457
780.00	2.2430	238.42	238.55	2.0858	.0525	.99546
800.00	2.2270	247.37	247.50	2.1585	.0524	.99620
820.00	2.2119	256.38	256.51	2.2315	.0523	.99682
840.00	2.1978	265.44	265.58	2.3049	.0521	.99733
860.00	2.1844	274.57	274.71	2.3786	.0520	.99777
880.00	2.1717	283.75	283.90	2.4526	.0519	.99813
900.00	2.1598	292.98	293.14	2.5269	.0517	.99843
920.00	2.1484	302.27	302.43	2.6015	.0516	.99868
940.00	2.1377	311.61	311.77	2.6763	.0515	.99889
960.00	2.1276	321.00	321.16	2.7513	.0513	.99907
1000.00	2.1088	339.98	340.15	2.9026	.0509	.99934

THE ELECTRON DENSITY OF HELIUM IS 3.010E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.384 BEV, AND THE MINIMUM ENERGY LOSS IS 1.9391 MEV/GM/CM2

## HYDROGEN(DIATOMIC)

ADJUSTED  
IONIZATION  
POTENTIAL  
18.30

ATOMIC  
WEIGHT  
1.0080

ATOMS/  
MOLECULE  
2

ATOMIC  
NUMBER  
1

ELEMENT  
H

DENSITY = .08988 MG/CM3

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE MG/CM2	PROTON RANGE METER	PATH LENGTH MG/CM2	PATH LENGTH METER	PATH LENGTH STRAGGLING MG/CM2	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	3480.7	.03252	.03362	.03258	.00362	.00066	.00067	.1800	0.
.15	2807.7	.04248	.00539	.04854	.00540	.00091	.00010	.1352	0.
.20	2330.8	.06724	.00756	.06806	.00757	.00121	.00013	.1290	0.
.30	1743.1	.11793	.01312	.11806	.01314	.00201	.00022	.1107	0.
.40	1407.2	.18201	.02021	.18221	.02027	.00303	.00034	.1081	0.
.50	1179.7	.25971	.02890	.25995	.02893	.00424	.00047	.1069	0.
.60	1017.7	.35110	.03906	.35147	.03910	.00566	.00063	.1060	0.
.70	910.67	.45483	.05066	.45531	.05066	.00722	.00080	.1053	0.
.80	813.91	.57086	.06351	.57145	.06358	.00893	.00099	.1046	0.
.90	748.89	.69865	.07773	.69938	.07781	.01079	.00120	.1039	0.
1.00	683.81	.83832	.09327	.83919	.09337	.01280	.00142	.1032	0.
1.20	591.74	1.1532	.12830	1.1543	.12843	.01728	.00192	.1020	0.
1.40	523.10	1.5130	.16834	1.5146	.16851	.02230	.00240	.1008	0.
1.60	469.79	1.9169	.21328	1.9188	.21349	.02783	.00310	.0998	0.
1.80	427.07	2.3637	.26298	2.3660	.26325	.03388	.00377	.0988	0.
2.00	392.02	2.8524	.31736	2.8552	.31767	.04043	.00450	.0979	0.
2.20	362.69	3.3826	.37635	3.3859	.37671	.04746	.00528	.0971	0.
2.40	337.75	3.9540	.43992	3.9578	.44035	.05497	.00612	.0964	0.
2.60	316.27	4.5658	.50799	4.5702	.50848	.06295	.00700	.0957	0.
2.80	297.56	5.2175	.58050	5.2225	.58105	.07140	.00794	.0951	0.
3.00	281.09	5.9087	.65740	5.9143	.65802	.08031	.00893	.0945	0.
3.20	266.49	6.6390	.73865	6.6453	.73935	.08966	.00998	.0939	0.
3.40	253.44	7.4082	.82423	7.4151	.82500	.09946	.01107	.0934	0.
3.60	241.71	8.2160	.91411	8.2237	.91496	.10970	.01221	.0929	0.
3.80	231.10	9.0617	1.0082	9.0700	1.0091	.12037	.01339	.0924	0.
4.00	221.41	9.9450	1.1065	9.9542	1.1075	.13148	.01463	.0920	0.
4.20	212.63	10.866	1.2090	10.876	1.2101	.14300	.01591	.0916	0.
4.40	204.54	11.825	1.3156	11.835	1.3168	.15495	.01724	.0912	0.
4.60	197.09	12.820	1.4264	12.832	1.4276	.16732	.01862	.0908	0.
4.80	190.20	13.852	1.5412	13.865	1.5426	.18010	.02004	.0905	0.

## HYDROGEN(DIATOMIC)

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM2	KEV/CH	GM/CM2	METER	GM/CM2	METER	GM/CM2	METER		
5.00	183.82	16.522	0.1492	1.6601	0.1493	1.6616	0.0019	0.2151	1.294	0.
5.50	169.72	15.254	0.1775	1.9751	0.1777	1.9769	0.0023	0.2537	1.283	0.
6.00	157.77	14.181	0.2081	2.3150	0.2083	2.3171	0.0027	0.2952	1.274	0.
6.50	147.51	13.258	0.2408	2.6796	0.2411	2.6820	0.0030	0.3393	1.265	0.
7.00	136.60	12.457	0.2758	3.0685	0.2760	3.0712	0.0035	0.3862	1.257	0.
7.50	130.78	11.754	0.3129	3.4816	0.3132	3.4846	0.0039	0.4357	1.250	0.
8.00	123.85	11.132	0.3522	3.9185	0.3525	3.9219	0.0044	0.4877	1.244	0.
8.50	117.68	10.577	0.3936	4.3791	0.3939	4.3828	0.0049	0.5424	1.238	0.
9.00	112.14	10.079	0.4371	4.8631	0.4375	4.8673	0.0054	0.5996	1.232	0.
9.50	107.13	9.6293	0.4827	5.3704	0.4831	5.3749	0.0059	0.6593	1.227	0.
10.00	102.59	9.2210	0.5304	5.9007	0.5308	5.9057	0.0065	0.7215	1.222	0.
11.00	94.653	8.5074	0.6318	7.0298	0.6324	7.0358	0.0077	0.8532	1.213	0.
12.00	87.939	7.9040	0.7414	8.2493	0.7421	8.2562	0.0089	0.9946	1.205	0.
13.00	82.184	7.3867	0.8591	9.5578	0.8598	9.5658	0.0103	1.1454	1.197	0.
14.00	77.191	6.9380	0.9846	10.954	0.9854	10.963	0.0117	1.3054	1.191	0.
15.00	72.817	6.5448	1.1179	12.438	1.1188	12.448	0.0133	1.4746	1.185	0.
16.00	68.950	6.1973	1.2590	14.008	1.2600	14.019	0.0149	1.6528	1.179	0.
17.00	65.507	5.8978	1.4077	15.662	1.4089	15.675	0.0165	1.8398	1.174	0.
18.00	62.419	5.6102	1.5640	17.402	1.5653	17.416	0.0183	2.0356	1.169	0.
19.00	59.634	5.3599	1.7279	19.224	1.7293	19.240	0.0201	2.2400	1.164	0.
20.00	57.108	5.1329	1.8991	21.130	1.9007	21.147	0.0220	2.4528	1.160	0.
22.00	52.700	4.7367	2.2638	25.187	2.2656	25.207	0.0261	2.9037	1.152	0.
24.00	48.979	4.4022	2.6574	29.566	2.6595	29.590	0.0304	3.3874	1.145	0.
26.00	45.793	4.1159	3.0797	34.264	3.0821	34.291	0.0351	3.9033	1.138	0.
28.00	43.034	3.8679	3.5301	39.276	3.5329	39.307	0.0400	4.4506	1.132	0.
30.00	40.619	3.6509	4.0084	44.597	4.0115	44.632	0.0452	5.0287	1.127	0.
32.00	38.488	3.4593	4.5140	50.223	4.5175	50.262	0.0507	5.6371	1.122	0.
34.00	36.592	3.2889	5.0461	56.150	5.0507	56.193	0.0564	6.2752	1.117	0.
36.00	34.893	3.1362	5.6063	62.375	5.6106	62.423	0.0624	6.9425	1.112	0.
38.00	33.363	2.9986	6.1922	68.894	6.1969	68.946	0.0687	7.6385	1.108	0.
40.00	31.976	2.8740	6.8042	75.703	6.8094	75.761	0.0752	8.3620	1.104	0.
45.00	29.018	2.6081	8.4467	93.978	8.4531	94.049	0.0925	1.0294	1.095	0.
50.00	26.619	2.3925	1.0246	114.00	1.0254	114.09	0.1114	1.2393	1.086	0.
55.00	24.633	2.2140	1.2199	135.73	1.2209	135.83	0.1317	1.4652	1.079	0.
60.00	22.960	2.0636	1.4302	159.12	1.4313	159.24	0.1534	1.7068	1.072	0.
65.00	21.531	1.9352	1.6551	184.14	1.6563	184.28	0.1765	1.9634	1.065	0.
70.00	20.295	1.8241	1.8942	210.75	1.8956	210.90	0.2008	2.2346	1.060	0.
75.00	19.216	1.7272	2.1475	239.91	2.1489	239.09	0.2265	2.5200	1.054	0.
80.00	18.265	1.6417	2.4141	268.60	2.4159	268.79	0.2534	2.8191	1.049	0.
90.00	16.666	1.4979	2.9877	332.41	2.9898	332.65	0.3107	3.4569	1.039	0.

## HYDROGEN(DIATOMIC)

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GM/CM2	KEV/CH	GM/CM2	METER	GM/CM2	METER	GM/CM2	METER PERCENT			
100.00	15.372	1.3816	3.6127	401.94	3.6153	402.23	.03726	4.1451	1.031	.0719	0.
110.00	14.303	1.2856	4.2872	476.99	4.2903	477.33	.04387	4.8810	1.023	.0715	0.
120.00	13.405	1.2049	5.0094	557.34	5.0130	557.74	.05089	5.6622	1.015	.0712	0.
130.00	12.640	1.1361	5.7775	642.81	5.7816	643.26	.05830	6.4864	1.008	.0708	0.
140.00	11.980	1.0768	6.5900	733.20	6.5947	733.72	.06608	7.3515	1.002	.0705	0.
150.00	11.405	1.0251	7.4453	828.36	7.4506	828.95	.07420	8.2556	.9959	.0703	0.
160.00	10.899	.97962	8.3420	928.13	8.3478	928.78	.08266	9.1968	.9902	.0700	0.
170.00	10.451	.93934	9.2786	1032.3	9.2851	1033.1	.09144	10.173	.9848	.0697	0.
180.00	10.051	.90340	10.254	1140.8	10.261	1141.6	.10052	11.184	.9796	.0695	0.
190.00	9.6923	.87114	11.267	1253.5	11.275	1254.4	.10989	12.227	.9747	.0693	0.
200.00	9.3683	.84202	12.316	1370.2	12.324	1371.2	.11955	13.301	.9700	.0691	0.
210.00	9.0745	.81561	13.400	1490.9	13.409	1491.9	.12946	14.404	.9655	.0689	0.
220.00	8.8068	.79155	14.518	1615.2	14.528	1616.4	.13964	15.536	.9612	.0687	0.
230.00	8.5619	.76954	15.669	1743.3	15.680	1744.5	.15006	16.695	.9570	.0685	0.
240.00	8.3371	.74934	16.852	1874.9	16.863	1876.2	.16071	17.880	.9530	.0684	0.
250.00	8.1360	.73072	18.066	2010.0	18.078	2011.4	.17159	19.091	.9491	.0682	0.
260.00	7.9366	.71352	19.310	2148.4	19.323	2149.9	.18268	20.325	.9454	.0681	0.
270.00	7.7613	.69759	20.583	2290.1	20.597	2291.6	.19398	21.583	.9418	.0679	0.
280.00	7.5966	.68278	21.885	2434.9	21.900	2436.6	.20549	22.862	.9383	.0678	0.
290.00	7.4431	.66899	23.214	2582.8	23.230	2584.5	.21718	24.163	.9342	.0676	0.
300.00	7.2999	.65611	24.570	2733.6	24.587	2735.5	.22906	25.485	.9316	.0675	.00002
310.00	7.1659	.64407	25.952	2887.4	25.969	2889.3	.24112	26.827	.9285	.0673	.00093
320.00	7.0403	.63278	27.359	3043.9	27.377	3046.0	.25335	28.187	.9254	.0672	.00202
330.00	6.9228	.62218	28.791	3203.2	28.810	3205.4	.26574	29.565	.9224	.0671	.00330
340.00	6.8114	.61221	30.246	3365.2	30.266	3367.4	.27830	30.963	.9195	.0670	.00477
350.00	6.7068	.60281	31.725	3529.7	31.746	3532.0	.29100	32.377	.9167	.0668	.00644
360.00	6.6082	.59394	33.226	3696.7	33.248	3699.2	.30386	33.807	.9139	.0667	.00832
370.00	6.5149	.58556	34.749	3866.2	34.772	3868.7	.31686	35.254	.9112	.0666	.01039
380.00	6.4267	.57763	36.294	4038.0	36.318	4040.7	.33000	36.715	.9086	.0665	.01268
390.00	6.3431	.57012	37.859	4212.2	37.884	4215.0	.34327	38.192	.9061	.0664	.01517
400.00	6.2638	.56299	39.445	4388.6	39.471	4391.5	.35667	39.683	.9036	.0662	.01787
410.00	6.1884	.55622	41.050	4567.2	41.077	4570.2	.37019	41.187	.9012	.0661	.02079
420.00	6.1168	.54977	42.674	4747.9	42.702	4751.0	.38384	42.705	.8989	.0660	.02393
430.00	6.0486	.54364	44.317	4930.7	44.346	4934.0	.39760	44.237	.8966	.0659	.02728
440.00	5.9836	.53780	45.978	5115.5	46.009	5118.9	.41147	45.780	.8943	.0658	.03085
450.00	5.9216	.53223	47.657	5302.3	47.689	5305.8	.42546	47.336	.8922	.0657	.03464
460.00	5.8624	.52691	49.354	5491.1	49.386	5494.7	.43955	48.904	.8900	.0656	.03864
470.00	5.8059	.52183	51.067	5681.7	51.100	5685.4	.45374	50.483	.8879	.0655	.04287
480.00	5.7518	.51697	52.796	5874.1	52.831	5877.9	.46804	52.073	.8859	.0654	.04731
490.00	5.7000	.51232	54.542	6068.3	54.577	6072.2	.48243	53.674	.8839	.0653	.05198

## HYDROGEN(DIATOMIC)

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON RANGE METER	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH METER	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	5.6505	56.303	6264.2	56.339	6268.3	.49691	.0652	.05686
510.00	5.6030	58.079	6461.8	58.117	6466.0	.51148	.0651	.06210
520.00	5.5574	59.870	6661.1	59.909	6665.4	.52814	.0650	.06786
530.00	5.5137	61.675	6862.0	61.715	6866.4	.54089	.0649	.07413
540.00	5.4717	63.495	7064.4	63.536	7069.0	.55572	.0648	.08091
550.00	5.4313	65.328	7268.4	65.370	7273.1	.57064	.0647	.08819
560.00	5.3925	67.175	7473.8	67.218	7478.7	.58563	.0646	.09596
570.00	5.3552	69.035	7680.7	69.079	7685.7	.60069	.0645	.10422
580.00	5.3192	70.907	7889.1	70.953	7894.2	.61583	.0645	.11295
590.00	5.2846	72.792	8098.8	72.839	8104.0	.63105	.0644	.12216
600.00	5.2512	74.689	8309.9	74.737	8315.2	.64633	.0643	.13181
620.00	5.1880	78.519	8736.0	78.569	8741.6	.67710	.0641	.15277
640.00	5.1292	82.394	9167.1	82.447	9173.0	.70813	.0639	.17601
660.00	5.0743	86.312	9603.0	86.367	9609.2	.73941	.0637	.20136
680.00	5.0230	90.272	10044.8	90.329	10050.1	.77092	.0636	.22862
700.00	4.9750	94.270	10488.8	94.330	10495.1	.80266	.0634	.25758
720.00	4.9300	98.306	10938.8	98.369	10944.1	.83461	.0632	.28801
740.00	4.8878	102.38	11391.1	102.44	11398.1	.86676	.0631	.31965
760.00	4.8481	106.48	11847.7	106.55	11855.1	.89911	.0629	.35211
780.00	4.8108	110.62	12308.8	110.59	12316.1	.93165	.0627	.38426
800.00	4.7757	114.79	12772.8	114.87	12780.1	.96436	.0626	.41586
820.00	4.7425	118.99	13239.1	119.07	13248.1	.99724	.0624	.44682
840.00	4.7113	123.22	13710.1	123.30	13718.1	1.0303	.0623	.47707
860.00	4.6818	127.48	14183.1	127.56	14192.1	1.0635	.0621	.50656
880.00	4.6538	131.76	14660.1	131.85	14669.1	1.0968	.0620	.53522
900.00	4.6274	136.07	15139.1	136.16	15149.1	1.1303	.0618	.56299
920.00	4.6024	140.41	15622.1	140.49	15631.1	1.1640	.0616	.58984
940.00	4.5787	144.77	16107.1	144.85	16116.1	1.1978	.0615	.61574
960.00	4.5563	149.15	16594.1	149.24	16604.1	1.2317	.0613	.64064
1000.00	4.5147	158.01	17580.1	158.11	17591.1	1.2999	.0608	.68740

THE ELECTRON DENSITY OF HYDROGEN(DIATOMIC) IS 5.977E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.501 BEV, AND THE MINIMUM ENERGY LOSS IS 4.1218 MEV/GM/CM2

IRON

ELEMENT  
FE

ATOMIC  
NUMBER  
26

ATOMS/  
MOLECULE  
1

ADJUSTED  
IONIZATION  
POTENTIAL  
273.0

ATOMIC  
WEIGHT  
55.847

DENSITY = 7.8700 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
		MG/CM2	MM	MG/CM2	MM	MG/CM2	MM			
.10	330.91	2604.3	.00059	.47840	.00061	.02066	.00003	4.318	2.239	0.
.15	314.43	2474.6	.00079	.63339	.00080	.02430	.00003	3.837	1.807	0.
.20	295.35	2324.4	.00100	.79743	.00101	.02791	.00004	3.500	1.623	0.
.30	263.65	2074.9	.00145	1.1556	.00147	.03531	.00004	3.056	1.448	0.
.40	227.15	1787.7	.00196	1.5635	.00199	.04386	.00006	2.805	1.349	0.
.50	197.26	1552.4	.00256	2.0376	.00259	.05527	.00007	2.712	1.279	0.
.60	179.80	1415.0	.00322	2.5695	.00326	.06849	.00009	2.665	1.227	0.
.70	161.81	1273.4	.00396	3.1548	.00401	.08301	.00011	2.631	1.185	0.
.80	149.10	1173.4	.00477	3.8010	.00483	.09917	.00013	2.609	1.151	0.
.90	141.43	1113.0	.00564	4.4387	.00570	.11568	.00015	2.577	1.122	0.
1.00	133.75	1052.6	.00656	5.2165	.00663	.13237	.00017	2.538	1.098	0.
1.20	119.72	942.22	.00855	6.8004	.00864	.16766	.00021	2.465	1.056	0.
1.40	109.03	858.04	.01076	8.4660	.01087	.20539	.00026	2.401	1.022	0.
1.60	100.40	790.12	.01317	10.364	.01330	.24530	.00031	2.343	.9941	0.
1.80	93.257	733.93	.01577	12.414	.01593	.28727	.00037	2.292	.9697	0.
2.00	87.257	686.71	.01857	14.615	.01875	.33120	.00042	2.245	.9484	0.
2.20	82.153	646.54	.02155	16.959	.02175	.37696	.00048	2.202	.9296	0.
2.40	77.748	611.87	.02470	19.442	.02493	.42442	.00054	2.163	.9127	0.
2.60	73.838	581.11	.02683	22.062	.02829	.47360	.00060	2.127	.8977	0.
2.80	70.365	553.77	.03153	24.817	.03181	.52446	.00067	2.095	.8841	0.
3.00	67.252	529.28	.03520	27.703	.03551	.57698	.00073	2.065	.8714	0.
3.20	64.442	507.16	.03903	30.719	.03937	.63115	.00080	2.037	.8600	0.
3.40	61.888	487.06	.04303	33.862	.04340	.68703	.00087	2.012	.8493	0.
3.60	59.555	468.70	.04718	37.133	.04758	.74498	.00095	1.989	.8395	.00001
3.80	57.413	451.84	.05150	40.529	.05193	.80495	.00102	1.970	.8303	.00001
4.00	55.438	436.29	.05597	44.050	.05644	.86685	.00110	1.952	.8218	.00001
4.20	53.611	421.92	.06060	47.693	.06110	.93063	.00118	1.935	.8138	.00001
4.40	51.915	408.57	.06538	51.457	.06592	.99824	.00127	1.920	.8063	.00002
4.60	50.333	396.12	.07032	55.343	.07089	1.0636	.00135	1.907	.7992	.00002
4.80	48.862	384.54	.07541	59.347	.07601	1.1328	.00144	1.894	.7925	.00003

IRON

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH CM	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING CM	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	47.446	373.71	.00807	.06397	.00813	.00120	.7863	.00003
5.50	44.406	349.48	.00944	.07429	.00951	.00139	.7719	.00005
6.00	41.752	328.59	.01091	.08583	.01099	.00158	.7591	.00008
6.50	39.434	310.34	.01246	.09802	.01256	.00179	.7478	.00011
7.00	37.382	294.20	.01411	.11102	.01421	.00200	.7377	.00015
7.50	35.551	279.79	.01584	.12465	.01596	.00222	.7285	.00019
8.00	33.921	266.96	.01766	.13896	.01779	.00245	.7201	.00025
8.50	32.441	255.31	.01956	.15394	.01970	.00269	.7124	.00031
9.00	31.125	244.95	.02155	.16959	.02170	.00294	.7055	.00037
9.50	29.922	235.49	.02362	.18585	.02376	.00319	.6990	.00045
10.00	28.819	226.81	.02577	.20279	.02595	.00346	.6930	.00053
11.00	26.867	211.45	.03031	.23852	.03052	.00401	.6822	.00072
12.00	25.190	198.25	.03516	.27675	.03540	.00459	.6727	.00058
13.00	23.732	186.77	.04033	.31742	.04060	.00520	.6643	.00202
14.00	22.451	176.69	.04581	.36050	.04611	.00584	.6568	.00336
15.00	21.316	167.75	.05158	.40596	.05192	.00651	.6500	.00580
16.00	20.302	159.78	.05766	.45377	.05803	.00721	.6439	.00825
17.00	19.392	152.61	.06403	.50388	.06444	.00793	.6383	.01071
18.00	18.569	146.14	.07068	.55628	.07113	.00868	.6332	.01320
19.00	17.822	140.26	.07763	.61136	.07812	.00945	.6285	.01571
20.00	17.139	134.88	.08486	.66786	.08539	.01027	.6242	.01824
22.00	15.937	125.43	.10016	.78827	.10078	.01196	.6163	.02334
24.00	14.912	117.36	.11656	.91736	.11728	.01375	.6096	.02852
26.00	14.026	110.39	.13405	1.0549	.13486	.01564	.6036	.03193
28.00	13.252	104.30	.15259	1.2009	.15351	.01763	.5982	.03351
30.00	12.570	99.927	.17218	1.3551	.17321	.01971	.5935	.03515
32.00	11.964	94.155	.19279	1.5173	.19394	.02189	.5892	.03686
34.00	11.421	89.883	.21442	1.6875	.21568	.02415	.5852	.03863
36.00	10.931	86.029	.23705	1.8656	.23842	.02650	.5817	.04047
38.00	10.488	82.544	.26066	2.0514	.26218	.02894	.5784	.04235
40.00	10.085	79.371	.28524	2.2448	.28689	.03147	.5754	.04429
45.00	9.3187	72.552	.35065	2.7770	.35286	.03814	.5688	.04936
50.00	8.5091	66.967	.42227	3.3421	.42467	.04532	.5632	.05449
55.00	7.9466	62.304	.49933	3.9518	.50214	.05297	.5585	.06029
60.00	7.4140	58.348	.58188	4.6049	.58512	.06108	.5544	.06616
65.00	6.9819	54.947	.66977	5.2711	.67348	.06964	.5509	.07226
70.00	6.6060	51.989	.76287	6.0038	.76707	.07863	.5477	.07858
75.00	6.2762	49.394	.867	6.8137	.86578	.08803	.5449	.08509
80.00	5.9839	47.093	.9643	7.6299	.96949	.09783	.5424	.09176
90.00	5.4903	43.209	1.1850	9.3767	1.1914	.11860	.5381	.10551



## IRON

PROTON ENERGY MEV	ENERGY LOSS rEV/ GM/CM2	PROTON RANGE		PATH LENGTH		GM/CM2	PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CH		GM/CM2	CH		
100.00	2.0282	11.210	1.4244	11.271	1.4321	1.4082	.01789	1.249	.5345	.11967
110.00	4.7540	13.235	1.6817	13.305	1.6906	.16442	.02089	1.236	.5315	.13427
120.00	4.4719	15.394	1.9560	15.476	1.9664	.18932	.02406	1.223	.5289	.14938
130.00	4.2303	17.682	2.2468	17.776	2.2587	.21545	.02738	1.212	.5267	.16490
140.00	4.0211	20.096	2.5535	20.202	2.5669	.24275	.03084	1.202	.5247	.18075
150.00	3.8383	22.629	2.8754	22.748	2.8905	.27115	.03445	1.192	.5230	.19664
160.00	3.6770	25.279	3.2120	25.411	3.2286	.30060	.03820	1.183	.5214	.21317
170.00	3.5337	28.040	3.5628	28.186	3.5815	.33105	.04207	1.175	.5200	.22976
180.00	3.4055	30.908	3.9274	31.070	3.9478	.36246	.04606	1.167	.5188	.24653
190.00	3.2902	33.861	4.3051	34.058	4.3275	.39476	.05016	1.159	.5176	.26345
200.00	3.1860	36.955	4.6957	37.147	4.7201	.42794	.05438	1.152	.5166	.28044
210.00	3.0912	40.126	5.0986	40.334	5.1250	.46193	.05870	1.145	.5156	.29749
220.00	3.0048	43.391	5.5135	43.616	5.5420	.49672	.06312	1.139	.5147	.31457
230.00	2.9256	46.748	5.9400	46.989	5.9707	.53226	.06763	1.133	.5139	.33163
240.00	2.8528	50.192	6.3776	50.451	6.4105	.56851	.07224	1.127	.5131	.34863
250.00	2.7857	53.722	6.8262	53.999	6.8613	.60546	.07693	1.121	.5124	.36555
260.00	2.7236	57.335	7.2852	57.630	7.3227	.64306	.08171	1.116	.5118	.38237
270.00	2.6660	61.027	7.7544	61.341	7.7943	.68129	.08657	1.111	.5111	.39908
280.00	2.6125	64.798	8.2335	65.130	8.2758	.72013	.09150	1.106	.5105	.41565
290.00	2.5626	68.644	8.7222	68.996	8.7669	.75955	.09651	1.101	.5100	.43205
300.00	2.5160	72.563	9.2202	72.934	9.2574	.79952	.10159	1.096	.5094	.44827
310.00	2.4723	76.553	9.7271	76.944	9.7769	.84003	.10674	1.092	.5089	.46429
320.00	2.4314	80.611	10.243	81.023	10.295	.88104	.11195	1.087	.5084	.48009
330.00	2.3930	84.736	10.767	85.169	10.822	.92255	.11722	1.083	.5079	.49566
340.00	2.3568	88.927	11.299	89.380	11.357	.96453	.12256	1.079	.5074	.51092
350.00	2.3227	93.180	11.840	93.655	11.900	1.0070	.12795	1.075	.5070	.52606
360.00	2.2905	97.494	12.388	97.990	12.451	1.0498	.13340	1.071	.5066	.54089
370.00	2.2601	101.87	12.944	102.39	13.010	1.0931	.13890	1.068	.5061	.55550
380.00	2.2313	106.30	13.507	106.84	13.575	1.1368	.14445	1.064	.5057	.56989
390.00	2.2040	110.79	14.077	111.35	14.148	1.1812	.15005	1.061	.5053	.58403
400.00	2.1781	115.33	14.654	115.91	14.728	1.2254	.15570	1.057	.5049	.59792
410.00	2.1535	119.92	15.238	120.53	15.314	1.2702	.16140	1.054	.5045	.61152
420.00	2.1301	124.57	15.828	125.20	15.908	1.3154	.16714	1.051	.5042	.62481
430.00	2.1078	129.26	16.425	129.92	16.508	1.3609	.17292	1.047	.5038	.63779
440.00	2.0866	134.01	17.028	134.69	17.114	1.4067	.17874	1.044	.5034	.65045
450.00	2.0664	138.80	17.637	139.50	17.726	1.4528	.18460	1.041	.5031	.66279
460.00	2.0471	143.64	18.252	144.37	18.344	1.4993	.19050	1.039	.5027	.67481
470.00	2.0287	148.52	18.872	149.27	18.967	1.5460	.19644	1.036	.5024	.68651
480.00	2.0110	153.45	19.498	154.22	19.593	1.5930	.20241	1.033	.5020	.69789
490.00	1.9942	158.42	20.129	159.22	20.231	1.6403	.20842	1.030	.5017	.70895

IRON

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PATH LENGTH		GM/CM2		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
500.00	1.9780	15.567	163.43	20.766	164.22	20.871	1.6878	.21446	1.028	.5013	.71970
510.00	1.9625	15.445	168.48	21.408	169.33	21.516	1.7356	.22054	1.025	.5010	.73914
520.00	1.9477	15.328	173.57	22.055	174.44	22.166	1.7837	.22664	1.022	.5006	.76026
530.00	1.9335	15.216	178.70	22.706	179.60	22.820	1.8319	.23277	1.020	.5003	.78208
540.00	1.9198	15.109	183.86	23.363	184.79	23.480	1.8804	.23894	1.018	.5000	.80360
550.00	1.9067	15.006	189.06	24.023	190.01	24.144	1.9292	.24513	1.015	.4996	.82483
560.00	1.8941	14.906	194.30	24.689	195.28	24.813	1.9781	.25135	1.013	.4993	.84576
570.00	1.8820	14.811	199.57	25.359	200.57	25.486	2.0273	.25759	1.011	.4989	.86640
580.00	1.8703	14.719	204.88	26.033	205.90	26.163	2.0766	.26386	1.009	.4986	.88676
590.00	1.8591	14.631	210.21	26.711	211.27	26.844	2.1262	.27016	1.006	.4983	.90684
600.00	1.8483	14.546	215.58	27.393	216.66	27.530	2.1759	.27648	1.004	.4979	.92666
620.00	1.8278	14.385	226.41	28.769	227.54	28.913	2.2759	.28919	1.000	.4973	.96549
640.00	1.8088	14.235	237.36	30.160	238.54	30.310	2.3766	.30198	.9963	.4966	.83932
660.00	1.7911	14.096	248.42	31.565	249.66	31.722	2.4780	.31486	.9926	.4960	.85218
680.00	1.7745	13.966	259.58	32.984	260.87	33.148	2.5799	.32782	.9890	.4953	.86413
700.00	1.7591	13.844	270.85	34.415	272.19	34.586	2.6825	.34085	.9855	.4946	.87521
720.00	1.7447	13.731	282.21	35.859	283.61	36.037	2.7856	.35395	.9822	.4940	.88549
740.00	1.7312	13.624	293.66	37.314	295.12	37.499	2.8892	.36711	.9790	.4933	.89498
760.00	1.7185	13.524	305.21	38.781	306.72	38.973	2.9933	.38034	.9759	.4926	.90376
780.00	1.7066	13.431	316.83	40.258	318.40	40.457	3.0978	.39362	.9729	.4919	.91186
800.00	1.6954	13.343	328.53	41.745	330.16	41.951	3.2028	.40697	.9701	.4913	.91974
820.00	1.6849	13.260	340.31	43.242	341.99	43.455	3.3082	.42036	.9674	.4906	.92727
840.00	1.6750	13.182	352.16	44.747	353.90	44.968	3.4141	.43381	.9647	.4899	.93457
860.00	1.6657	13.109	364.08	46.262	365.87	46.490	3.5203	.44730	.9622	.4892	.94140
880.00	1.6569	13.040	376.07	47.785	377.91	48.020	3.6268	.46084	.9597	.4885	.94775
900.00	1.6487	12.975	388.12	49.316	390.02	49.558	3.7337	.47443	.9573	.4878	.95367
920.00	1.6409	12.914	400.23	50.855	402.19	51.104	3.8410	.48805	.9550	.4871	.95918
940.00	1.6335	12.855	412.41	52.403	414.42	52.659	3.9485	.50172	.9528	.4863	.96432
960.00	1.6265	12.801	424.65	53.958	426.72	54.221	4.0564	.51542	.9506	.4854	.96910
1000.00	1.6137	12.700	449.42	57.105	451.60	57.382	4.2730	.54294	.9462	.4830	.98774

THE ELECTRON DENSITY OF IRON IS 2.805E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.100 SEV, AND THE MINIMUM ENERGY LOSS IS 1.5124 MEV/GM/CM2

# KRYPTON

ATOMIC ELEMENT NUMBER 36  
 ATOMS/ MOLECULE 1  
 ATOMIC WEIGHT 83.800  
 ADJUSTED IONIZATION POTENTIAL 358.4

DENSITY = 3.4900 MG/CM<sup>3</sup>

PROCTON ENERGY MEV	ENERGY LOSS KEV/CM	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		MG/CM <sup>2</sup>	METER	MG/CM <sup>2</sup>	METER	MG/CM <sup>2</sup>	METER PERCENT		
.10	284.78	.40305	.00115	.41500	.00119	.01886	.00005	2.880	0.
.15	247.87	.58999	.00169	.60304	.00173	.02425	.00007	2.165	0.
.20	220.01	.80146	.00230	.81704	.00234	.03117	.00009	1.908	0.
.30	182.07	1.2958	.00371	1.3189	.00378	.04742	.00014	1.743	0.
.40	158.48	1.8771	.00538	1.9095	.00547	.06552	.00019	1.694	0.
.50	143.02	2.5320	.00726	2.5750	.00738	.08454	.00024	1.668	0.
.60	131.99	3.2491	.00931	3.3035	.00947	.10391	.00030	1.647	0.
.70	122.95	4.0220	.01152	4.0885	.01171	.12356	.00035	1.625	0.
.80	116.01	4.8469	.01389	4.9259	.01411	.14347	.00041	1.605	0.
.90	110.00	5.7188	.01639	5.8108	.01665	.16406	.00047	1.583	0.
1.00	103.99	6.6405	.01903	6.7459	.01933	.18590	.00053	1.562	0.
1.20	94.346	8.6347	.02474	8.7680	.02512	.23336	.00067	1.520	0.
1.40	86.696	10.819	.03100	10.982	.03147	.28365	.00081	1.482	0.
1.60	80.356	13.187	.03779	13.381	.03834	.33720	.00097	1.447	0.
1.80	75.102	15.730	.04507	15.956	.04572	.39338	.00113	1.415	0.
2.00	70.699	18.445	.05285	18.704	.05359	.45178	.00129	1.386	0.
2.20	66.843	21.320	.06109	21.614	.06193	.51229	.00147	1.360	0.
2.40	63.441	24.356	.06979	24.686	.07073	.57491	.00165	1.336	0.
2.60	60.416	27.551	.07894	27.917	.07999	.63962	.00183	1.314	0.
2.80	57.716	30.901	.08854	31.306	.08970	.70637	.00202	1.293	0.
3.00	55.283	34.403	.09858	34.847	.09985	.77513	.00222	1.274	0.
3.20	53.079	38.057	.10904	38.541	.11043	.84586	.00242	1.257	0.
3.40	51.068	41.838	.11994	42.384	.12144	.91853	.00263	1.240	0.
3.60	49.223	45.807	.13125	46.375	.13288	.99314	.00285	1.225	0.
3.80	47.530	49.896	.14297	50.508	.14472	1.0696	.00306	1.211	0.
4.00	45.986	54.132	.15511	54.788	.15699	1.1480	.00329	1.197	0.
4.20	44.528	58.505	.16764	59.209	.16965	1.2282	.00352	1.185	0.
4.40	43.206	63.023	.18058	63.771	.18272	1.3101	.00375	1.173	0.
4.60	41.971	67.671	.19390	68.466	.19618	1.3937	.00399	1.162	0.
4.80	40.814	72.456	.20761	73.299	.21003	1.4790	.00424	1.151	.00901

KRYPTON

PROTON ENERGY MEV	ENERGY LOSS KEV/CM2	PROTON RANGE METER	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	39.728	138.65	.07737	.22170	.00157	.00001
5.50	37.282	130.11	.09025	.26151	.00177	.00001
6.00	35.169	122.74	.10393	.30109	.00203	.00002
6.50	33.312	116.26	.11840	.34297	.00227	.00004
7.00	31.660	110.49	.13366	.38711	.00252	.00005
7.50	30.187	105.35	.14969	.43346	.00279	.00008
8.00	28.860	100.72	.16648	.47702	.00307	.00011
8.50	27.658	96.525	.18402	.52729	.00336	.00014
9.00	26.563	92.706	.20231	.57969	.00366	.00018
9.50	25.562	89.212	.22133	.63419	.00396	.00023
10.00	24.643	86.003	.24108	.69077	.00428	.00028
11.00	23.012	80.310	.28274	.81815	.00495	.00041
12.00	21.608	75.412	.32723	.94668	.00565	.00057
13.00	20.386	71.146	.37449	1.0730	.00639	.00074
14.00	19.310	67.391	.42449	1.2163	.00717	.00095
15.00	18.353	64.052	.47719	1.3673	.00798	.00118
16.00	17.496	61.062	.53255	1.5259	.00882	.00211
17.00	16.729	58.384	.59055	1.6921	.00969	.00352
18.00	16.029	55.941	.65115	1.8657	.01060	.00569
19.00	15.452	53.754	.71430	2.0467	.01154	.00788
20.00	14.829	51.752	.77992	2.2347	.01251	.01009
22.00	13.815	48.214	.91863	2.6322	.01453	.01456
24.00	12.947	45.185	1.0671	3.0575	.01667	.01910
26.00	12.194	42.558	1.2251	3.5104	.01893	.02215
28.00	11.535	40.257	1.3925	3.9900	.02129	.02363
30.00	10.952	38.223	1.5692	4.4963	.02376	.02518
32.00	10.433	36.411	1.7549	5.0285	.02634	.02678
34.00	9.9677	34.787	1.9496	5.5862	.02902	.02845
36.00	9.5478	33.322	2.1531	6.1694	.03190	.03016
38.00	9.1671	31.993	2.3654	6.7775	.03469	.03194
40.00	8.8200	30.782	2.5862	7.4102	.03766	.03376
45.00	8.0729	28.174	3.1750	9.0976	.04553	.03850
50.00	7.4643	26.050	3.8152	10.932	.05396	.04350
55.00	6.9510	24.259	4.5047	12.907	.06293	.04874
60.00	6.5151	22.738	5.2427	15.022	.07242	.05425
65.00	6.1399	21.428	6.0283	17.273	.08242	.06000
70.00	5.8134	20.289	6.8594	19.655	.09292	.06597
75.00	5.5263	19.287	7.7355	22.165	.10389	.07213
80.00	5.2723	18.400	8.6557	24.801	.11531	.07646
90.00	4.8420	16.898	10.623	30.439	.13948	.09158
					.35965	
					1.303	
					1.445	
					1.423	
					1.403	
					1.386	
					1.371	
					1.357	
					1.344	
					1.333	
					1.322	
					1.303	
					1.284	
					1.264	
					1.241	
					1.213	
					1.182	
					1.145	
					1.100	
					1.055	
					1.011	
					0.968	
					0.926	
					0.885	
					0.845	
					0.806	
					0.768	
					0.731	
					0.695	
					0.660	
					0.625	
					0.591	
					0.558	
					0.525	
					0.493	
					0.461	
					0.430	
					0.399	
					0.369	
					0.339	
					0.310	
					0.281	
					0.253	
					0.225	
					0.198	
					0.171	
					0.145	
					0.118	
					0.092	
					0.066	
					0.041	
					0.016	
					0.001	

KRYPTON

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH METER	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING METER	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	4.4910	12.755	12.849	36.817	.16530	.47364	1.286	.10518
110.00	4.1991	15.043	15.154	43.420	.19269	.55212	1.272	.11925
120.00	3.9523	17.482	17.610	50.458	.22155	.63482	1.258	.13380
130.00	3.7410	20.066	20.212	57.914	.25181	.72151	1.246	.14874
140.00	3.5574	22.789	22.955	65.772	.28339	.81201	1.235	.16398
150.00	3.3971	25.647	25.832	74.018	.31623	.90611	1.224	.17946
160.00	3.2558	28.634	28.840	82.637	.35026	1.0036	1.214	.19518
170.00	3.1302	31.745	31.974	91.615	.38542	1.1043	1.205	.21117
180.00	3.0178	34.977	35.228	100.94	.42165	1.2082	1.197	.22736
190.00	2.9166	38.325	38.600	110.60	.45890	1.3149	1.189	.24372
200.00	2.8250	41.786	42.084	120.59	.49713	1.4244	1.181	.26018
210.00	2.7418	45.353	45.676	130.88	.53629	1.5366	1.174	.27671
220.00	2.6659	49.026	49.375	141.48	.57633	1.6514	1.167	.29325
230.00	2.5963	52.802	53.177	152.37	.61722	1.7686	1.161	.30976
240.00	2.5323	56.675	57.077	163.54	.65893	1.8860	1.154	.32622
250.00	2.4733	60.644	61.073	174.99	.70141	2.0098	1.148	.34259
260.00	2.4167	64.705	65.162	186.71	.74463	2.1336	1.143	.35888
270.00	2.3680	68.855	69.341	198.68	.78856	2.2595	1.137	.37513
280.00	2.3209	73.091	73.607	210.91	.83316	2.3873	1.132	.39131
290.00	2.2770	77.412	77.957	223.37	.87842	2.5170	1.127	.40738
300.00	2.2359	81.814	82.389	236.07	.92431	2.6485	1.122	.42334
310.00	2.1975	86.294	86.901	249.00	.97079	2.7816	1.117	.43915
320.00	2.1615	90.851	91.489	262.15	1.0179	2.9165	1.113	.45482
330.00	2.1276	95.483	96.153	275.51	1.0655	3.0529	1.108	.47033
340.00	2.0958	100.19	100.89	289.08	1.1136	3.1908	1.104	.48565
350.00	2.0657	104.96	105.69	302.85	1.1623	3.3302	1.100	.50077
360.00	2.0374	109.80	110.57	316.82	1.2114	3.4710	1.096	.51567
370.00	2.0106	114.71	115.51	330.97	1.2610	3.6132	1.092	.53033
380.00	1.9852	119.68	120.52	345.32	1.3111	3.7566	1.088	.54473
390.00	1.9612	124.71	125.58	359.84	1.3616	3.9013	1.084	.55886
400.00	1.9384	129.81	130.71	374.53	1.4125	4.0472	1.081	.57272
410.00	1.9167	134.96	135.90	389.40	1.4638	4.1942	1.077	.58631
420.00	1.8961	140.17	141.15	404.43	1.5155	4.3424	1.074	.59963
430.00	1.8765	145.44	146.45	419.62	1.5676	4.4916	1.070	.61266
440.00	1.8578	150.75	151.80	434.97	1.6200	4.6419	1.067	.62541
450.00	1.8400	156.13	157.21	450.47	1.6728	4.7931	1.064	.63787
460.00	1.8230	161.55	162.67	466.11	1.7259	4.9453	1.061	.65005
470.00	1.8067	167.02	168.18	481.90	1.7794	5.0985	1.058	.66193
480.00	1.7912	172.54	173.74	497.83	1.8331	5.2525	1.055	.67352
490.00	1.7763	178.11	179.35	513.89	1.8872	5.4074	1.052	.68482

# KRYPTON

PRCTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON RANGE METER	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH METER	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING METER	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.7621	183.73	526.44	185.00	530.09	1.9415	5.5632	.6882	.69583
510.00	1.7485	189.39	542.65	190.70	546.41	1.9962	5.7197	.6878	.70654
520.00	1.7354	195.09	558.99	196.44	562.86	2.0511	5.8770	.6874	.71697
530.00	1.7229	200.83	575.45	202.22	579.43	2.1063	6.0351	.6869	.72711
540.00	1.7108	206.62	592.03	208.05	596.12	2.1617	6.1939	.6865	.73696
550.00	1.6993	212.44	608.72	213.91	612.92	2.2173	6.3534	.6861	.74654
560.00	1.6882	218.31	625.52	219.81	629.84	2.2732	6.5136	.6857	.75583
570.00	1.6775	224.21	642.43	225.76	646.87	2.3294	6.6744	.6853	.76486
580.00	1.6672	230.15	659.45	231.74	664.00	2.3857	6.8359	.6849	.77361
590.00	1.6574	236.12	676.57	237.75	681.24	2.4423	6.9980	.6845	.78209
600.00	1.6478	242.13	693.79	243.80	698.57	2.4991	7.1607	.6841	.79031
620.00	1.6298	254.26	728.53	256.01	733.54	2.6133	7.4879	.6832	.80598
640.00	1.6131	266.51	763.64	268.34	768.89	2.7282	7.8172	.6824	.82066
660.00	1.5975	278.89	799.10	280.80	804.58	2.8438	8.1485	.6816	.83439
680.00	1.5830	291.38	834.90	293.38	840.62	2.9601	8.4818	.6808	.84721
700.00	1.5684	303.98	871.02	306.07	876.98	3.0771	8.8169	.6800	.85916
720.00	1.5567	316.70	907.44	318.86	913.64	3.1946	9.1537	.6791	.87028
740.00	1.5448	329.51	944.15	331.76	950.60	3.3128	9.4921	.6783	.88063
760.00	1.5337	342.42	981.13	344.75	987.83	3.4314	9.8321	.6775	.89024
780.00	1.5233	355.41	1018.4	357.84	1025.3	3.5506	10.174	.6767	.89915
800.00	1.5135	368.50	1055.9	371.01	1063.1	3.6702	10.516	.6758	.90740
820.00	1.5043	381.67	1093.6	384.27	1101.0	3.7903	10.860	.6750	.91504
840.00	1.4956	394.92	1131.6	397.60	1139.3	3.9108	11.206	.6742	.92211
860.00	1.4874	408.25	1169.8	411.01	1177.7	4.0318	11.552	.6733	.92863
880.00	1.4797	421.64	1208.1	424.50	1216.3	4.1531	11.900	.6725	.93465
900.00	1.4725	435.13	1246.8	438.07	1255.2	4.2748	12.249	.6716	.94020
920.00	1.4657	448.67	1285.6	451.70	1294.3	4.3969	12.598	.6707	.94531
940.00	1.4592	462.27	1324.6	465.39	1333.5	4.5193	12.949	.6697	.95032
960.00	1.4531	475.95	1363.8	479.16	1372.9	4.6420	13.301	.6685	.95434
1000.00	1.4419	503.63	1443.1	507.01	1452.7	4.8884	14.007	.6654	.96193

THE ELECTRON DENSITY OF KRYPTON IS 2.588E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.052 BEV, AND THE MINIMUM ENERGY LOSS IS 3.3557 MEV/GM/CM2

# LEAD

ELEMENT  
 PB  
 ATOMIC  
 NUMBER  
 82  
 ATOMS/  
 MOLECULE  
 1  
 ATOMIC  
 WEIGHT  
 207.19  
 ADJUSTED  
 IONIZATION  
 POTENTIAL  
 810.0

DENSITY = 11.340 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE MG/CM <sup>2</sup>	PROTON PATH LENGTH MM	MG/CM <sup>2</sup>	PATH LENGTH STRAGGLING MM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	121.90	1.2924	.00114	1.2668	.00121	.07000	5.445	0.
.15	127.51	1.6887	.00149	1.7678	.00156	.08295	4.473	0.
.20	126.11	2.0732	.00183	2.1620	.00191	.09343	4.111	0.
.30	113.18	2.8805	.00254	2.9959	.00264	.11567	3.850	0.
.40	99.802	3.7904	.00334	3.9383	.00347	.14470	3.755	0.
.50	90.308	4.8082	.00424	4.9932	.00440	.17847	3.705	0.
.60	82.632	5.9256	.00523	6.1513	.00542	.21523	3.669	0.
.70	77.074	7.1349	.00629	7.4042	.00653	.25399	3.638	0.
.80	70.991	8.4403	.00744	8.7561	.00772	.29514	3.607	0.
.90	67.040	9.8395	.00868	10.205	.00900	.33857	3.578	0.
1.00	63.087	11.326	.00999	11.743	.01036	.38351	3.549	0.
1.20	58.206	14.519	.01280	15.045	.01327	.47561	3.494	0.
1.40	54.152	17.969	.01585	18.610	.01641	.56882	3.442	0.
1.60	50.732	21.669	.01911	22.430	.01978	.66578	3.390	0.
1.80	47.812	25.610	.02258	26.495	.02336	.76883	3.340	0.
2.00	45.273	29.790	.02626	30.794	.02716	.87689	3.292	0.
2.20	43.075	34.177	.03014	35.324	.03115	.98930	3.246	0.
2.40	41.186	38.791	.03421	40.074	.03534	1.1049	3.203	0.
2.60	39.479	43.617	.03846	45.041	.03972	1.2234	3.162	0.
2.80	37.929	48.637	.04289	50.205	.04427	1.3449	3.124	0.
3.00	36.515	53.865	.04750	55.580	.04901	1.4691	3.086	0.
3.20	35.219	59.292	.05229	61.158	.05393	1.5961	3.052	0.
3.40	34.027	64.917	.05725	66.938	.05903	1.7259	3.019	0.
3.60	32.925	70.739	.06238	72.917	.06430	1.8584	2.987	0.
3.80	31.905	76.748	.06768	79.086	.06974	1.9936	2.957	0.
4.00	30.956	82.948	.07315	85.450	.07535	2.1315	2.928	0.
4.20	30.071	89.343	.07879	92.012	.08114	2.2719	2.901	0.
4.40	29.245	95.912	.08458	98.751	.08708	2.4150	2.875	0.
4.60	28.471	102.67	.09054	105.68	.09320	2.5605	2.850	0.
4.80	27.745	109.62	.09667	112.81	.09948	2.7086	2.826	0.

## LEAD

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	CH	PROTON PATH LENGTH GM/CM2	CH	PATH LENGTH STRAGGLING GM/CM2	CH	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	27.062	306.88	.11673	.01029	.12010	.01059	.00286	.00025	2.381	0.
5.50	25.518	289.37	.13531	.01193	.13914	.01227	.00325	.00029	2.333	0.
6.00	24.162	274.00	.15498	.01367	.15928	.01405	.00365	.00032	2.290	0.
6.50	22.974	260.53	.17571	.01549	.18052	.01592	.00406	.00036	2.252	0.
7.00	21.910	248.46	.19752	.01742	.20283	.01789	.00450	.00040	2.217	0.
7.50	20.976	237.87	.22029	.01943	.22614	.01994	.00494	.00044	2.187	0.
8.00	20.131	228.29	.24410	.02153	.25050	.02209	.00541	.00048	2.160	0.
8.50	19.363	219.58	.26888	.02371	.27584	.02432	.00589	.00052	2.136	0.
9.00	18.662	211.65	.29462	.02598	.30215	.02664	.00639	.00056	2.115	0.
9.50	18.016	204.32	.32125	.02833	.32940	.02905	.00690	.00061	2.095	0.
10.00	17.424	197.59	.34990	.03077	.35764	.03154	.00743	.00065	2.076	.00001
11.00	16.360	185.53	.40692	.03588	.41691	.03676	.00852	.00075	2.043	.00002
12.00	15.526	176.07	.46838	.04130	.47969	.04230	.00965	.00085	2.012	.00004
13.00	14.716	166.80	.53325	.04702	.54594	.04814	.01083	.00095	1.983	.00007
14.00	13.998	158.74	.60150	.05304	.61560	.05429	.01205	.00107	1.958	.00012
15.00	13.361	151.52	.67312	.05936	.68870	.06073	.01332	.00117	1.934	.00019
16.00	12.788	145.02	.74839	.06597	.76519	.06748	.01463	.00129	1.912	.00028
17.00	12.270	139.14	.82659	.07289	.84527	.07454	.01599	.00141	1.892	.00039
18.00	11.797	133.78	.90803	.08007	.92834	.08186	.01739	.00153	1.873	.00053
19.00	11.367	128.90	.99260	.08753	1.0146	.08947	.01883	.00166	1.856	.00068
20.00	10.971	124.42	1.0806	.09529	1.1043	.09738	.02031	.00179	1.839	.00086
22.00	10.270	116.46	1.2654	.11158	1.2927	.11399	.02338	.00206	1.809	.00129
24.00	9.6660	109.61	1.4626	.12897	1.4937	.13172	.02661	.00235	1.782	.00179
26.00	9.1401	103.65	1.6713	.14738	1.7064	.15048	.02999	.00264	1.757	.00274
28.00	8.6772	98.399	1.8922	.16686	1.9314	.17031	.03351	.00295	1.735	.00412
30.00	8.2656	93.732	2.1240	.18730	2.1675	.19114	.03717	.00328	1.715	.00556
32.00	7.8957	89.537	2.3671	.20874	2.4151	.21298	.04096	.00361	1.696	.00705
34.00	7.5678	85.819	2.6213	.23115	2.6739	.23579	.04489	.00396	1.679	.00860
36.00	7.2705	82.447	2.8862	.25452	2.9437	.25958	.04894	.00432	1.663	.01019
38.00	7.0162	79.564	3.1611	.27876	3.2235	.28426	.05310	.00468	1.647	.01183
40.00	6.7662	76.728	3.4470	.30396	3.5145	.30992	.05737	.00506	1.632	.01351
45.00	6.2246	70.587	4.2040	.37072	4.2851	.37787	.06857	.00605	1.600	.01790
50.00	5.7780	65.523	5.0243	.44306	5.1198	.45148	.08055	.00710	1.573	.02252
55.00	5.4023	61.262	5.9046	.52068	6.0154	.53046	.09327	.00822	1.550	.02738
60.00	5.0810	57.618	6.8432	.60346	6.9703	.61466	.10668	.00941	1.530	.03248
65.00	4.8027	54.463	7.8389	.69126	7.9831	.70398	.12076	.01065	1.513	.03781
70.00	4.5593	51.703	8.8903	.78398	9.0524	.79827	.13547	.01195	1.497	.04335
75.00	4.3447	49.269	9.9952	.88141	10.176	.89736	.15080	.01330	1.482	.04908
80.00	4.1538	47.105	11.153	.98347	11.353	.99736	.16671	.01470	1.468	.05499
90.00	3.8288	43.419	13.617	1.2008	13.859	1.2221	.20023	.01766	1.445	.06728



## LEAD

PROTON ENERGY MEV	ENERGY LOSS MEV/CM GM/CM2	PROTON RANGE CM/CH2 CM	PROTON PATH LENGTH GM/CM2 CM	PATH LENGTH STRAGGLING GM/CM2 CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION%
190.00	3.5622	16.282	16.568	.23587	1.727	.08011
110.00	3.3395	19.137	19.470	.27352	1.712	.09344
120.00	3.1514	22.166	22.549	.31300	1.699	.10727
130.00	2.9895	25.373	25.808	.35422	1.689	.12151
140.00	2.8488	28.745	29.236	.39709	1.679	.13611
150.00	2.7254	32.276	32.825	.44152	1.671	.15099
160.00	2.6162	35.962	36.571	.48742	1.664	.16616
170.00	2.5189	39.796	40.467	.53472	1.657	.18163
180.00	2.4317	43.773	44.508	.58335	1.652	.19734
190.00	2.3530	47.882	48.684	.63324	1.646	.21325
200.00	2.2818	52.130	53.000	.68434	1.641	.22931
210.00	2.2170	56.505	57.446	.73658	1.637	.24544
220.00	2.1577	61.005	62.018	.78992	1.633	.26155
230.00	2.1055	65.617	66.704	.84413	1.630	.27758
240.00	2.0553	70.353	71.516	.89935	1.626	.29352
250.00	2.0089	75.200	76.441	.95553	1.623	.30935
260.00	1.9660	80.141	81.461	1.0126	1.620	.32512
270.00	1.9262	85.202	86.603	1.0706	1.618	.34087
280.00	1.8892	90.365	91.848	1.1294	1.615	.35658
290.00	1.8546	95.626	97.194	1.1890	1.613	.37224
300.00	1.8223	100.98	102.64	1.2494	1.610	.38781
310.00	1.7921	106.43	108.17	1.3105	1.608	.40329
320.00	1.7637	111.95	113.78	1.3722	1.607	.41869
330.00	1.7360	117.57	119.49	1.4347	1.605	.43397
340.00	1.7109	123.29	125.30	1.4979	1.603	.44914
350.00	1.6872	129.09	131.19	1.5618	1.602	.46416
360.00	1.6649	134.95	137.15	1.6262	1.600	.47899
370.00	1.6438	140.90	143.19	1.6911	1.598	.49356
380.00	1.6237	146.93	149.31	1.7566	1.597	.50787
390.00	1.6048	153.02	155.50	1.8226	1.595	.52191
400.00	1.5868	159.26	161.84	1.8892	1.594	.53569
410.00	1.5697	165.50	168.18	1.9561	1.593	.54921
420.00	1.5535	171.80	174.58	2.0236	1.591	.56249
430.00	1.5380	178.17	181.05	2.0915	1.590	.57554
440.00	1.5233	184.60	187.58	2.1598	1.589	.58835
450.00	1.5092	191.10	194.18	2.2285	1.588	.60131
460.00	1.4958	197.65	200.84	2.2976	1.586	.61321
470.00	1.4830	204.26	207.55	2.3671	1.586	.62526
480.00	1.4708	210.87	214.26	2.4370	1.585	.63705
490.00	1.4591	217.59	221.09	2.5072	1.584	.64858

## LEAD

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	CH	PROTON PATH LENGTH GM/CM2	CH	PATH LENGTH STRAGGLING GM/CM2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.4479	16.419	224.36	19.785	227.97	20.103	2.5772	1.131	.65986
510.00	1.4371	16.297	231.16	20.384	234.87	20.712	2.6484	1.128	.67087
520.00	1.4269	16.181	238.03	20.990	241.88	21.328	2.7198	1.125	.68162
530.00	1.4170	16.069	244.95	21.601	248.88	21.947	2.7913	1.122	.69210
540.00	1.4075	15.961	251.92	22.215	255.96	22.572	2.8631	1.119	.70233
550.00	1.3984	15.858	258.93	22.834	263.09	23.200	2.9351	1.116	.71230
560.00	1.3897	15.759	265.99	23.456	270.26	23.832	3.0075	1.113	.72202
570.00	1.3813	15.664	273.10	24.083	277.47	24.469	3.0800	1.110	.73148
580.00	1.3732	15.572	280.24	24.713	284.73	25.109	3.1529	1.107	.74068
590.00	1.3655	15.484	287.43	25.347	292.03	25.753	3.2260	1.105	.74964
600.00	1.3580	15.399	294.70	25.987	299.41	26.403	3.2993	1.102	.75835
620.00	1.3438	15.239	309.32	27.277	314.26	27.713	3.4466	1.097	.77504
640.00	1.3307	15.090	324.18	28.587	329.35	29.043	3.5948	1.091	.79078
660.00	1.3185	14.952	339.06	29.899	344.46	30.376	3.7438	1.087	.80560
680.00	1.3071	14.823	354.07	31.223	359.70	31.720	3.8935	1.082	.81954
700.00	1.2965	14.702	369.20	32.558	375.07	33.075	4.0439	1.078	.83262
720.00	1.2866	14.590	384.43	33.903	390.57	34.442	4.1950	1.074	.84489
740.00	1.2773	14.485	399.83	35.253	406.18	35.818	4.3466	1.070	.85638
760.00	1.2686	14.386	415.31	36.624	421.90	37.204	4.4989	1.066	.86713
780.00	1.2605	14.294	430.90	37.998	437.72	38.600	4.6517	1.063	.87716
800.00	1.2529	14.207	446.38	39.381	453.65	40.004	4.8050	1.059	.88653
820.00	1.2457	14.126	462.36	40.773	469.67	41.417	4.9589	1.056	.89525
840.00	1.2389	14.050	478.23	42.172	485.78	42.838	5.1131	1.053	.90338
860.00	1.2326	13.978	494.18	43.579	501.98	44.266	5.2679	1.049	.91094
880.00	1.2266	13.910	510.22	44.993	518.26	45.702	5.4230	1.046	.91796
900.00	1.2210	13.846	526.35	46.415	534.63	47.145	5.5786	1.043	.92447
920.00	1.2157	13.786	542.54	47.843	551.07	48.595	5.7345	1.041	.93052
940.00	1.2107	13.730	558.82	49.279	567.59	50.052	5.8908	1.038	.93612
960.00	1.2060	13.676	575.17	50.721	584.18	51.515	6.0474	1.035	.94130
1000.00	1.1974	13.579	608.28	53.640	617.78	54.478	6.3616	1.030	.95048

THE ELECTRON DENSITY OF LEAD IS 2.384E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.916 MEV, AND THE MINIMUM ENERGY LOSS IS 1.1338 MEV/GM/CM2

ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL
Li	3	1	6.9390	38.80

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GM/CM2	HEV/CH	MG/CM2	MM	MG/CM2	MM	MG/CM2	MM			
.10	751.84	398.48	.13672	.00258	.13730	.00259	.00385	.00007	2.806	.4211	0.
.15	675.80	358.17	.20679	.00350	.20741	.00391	.00557	.00011	2.688	.3009	0.
.20	606.44	321.41	.28476	.00537	.28548	.00539	.00725	.00014	2.540	.2516	0.
.30	495.71	262.73	.46737	.00882	.46834	.00884	.01087	.00021	2.320	.2067	0.
.40	418.70	221.91	.68718	.01297	.68846	.01299	.01501	.00028	2.180	.1845	0.
.50	363.27	192.53	.94366	.01780	.94527	.01784	.01970	.00037	2.084	.1707	0.
.60	320.54	169.89	1.23367	.02333	1.2387	.02337	.02494	.00057	2.015	.1610	0.
.70	288.06	152.67	1.5652	.02953	1.5676	.02958	.03070	.00058	1.958	.1530	0.
.80	261.99	138.85	1.9288	.03639	1.9317	.03645	.03696	.00070	1.914	.1480	0.
.90	253.44	134.33	2.3159	.04370	2.3192	.04376	.04325	.00082	1.865	.1435	0.
1.00	244.87	129.78	2.7173	.05127	2.7211	.05134	.04918	.00093	1.808	.1397	0.
1.20	214.46	113.66	3.5909	.06775	3.5957	.06784	.06179	.00117	1.718	.1332	.00001
1.40	191.27	101.37	4.5792	.08640	4.5851	.08651	.07613	.00144	1.660	.1278	.00001
1.60	172.96	91.669	5.6794	.10716	5.6864	.10729	.09207	.00174	1.619	.1234	.00002
1.80	158.11	83.798	6.8889	.12998	6.8971	.13013	.10952	.00207	1.588	.1197	.00004
2.00	145.80	77.273	8.2062	.15483	8.2158	.15501	.12839	.00242	1.563	.1165	.00007
2.20	135.41	71.769	9.6291	.18168	9.6400	.18189	.14862	.00280	1.542	.1138	.00010
2.40	126.53	67.059	11.156	.21050	11.169	.21073	.17019	.00321	1.524	.1115	.00014
2.60	118.83	62.577	12.787	.24126	12.801	.24153	.19305	.00364	1.508	.1095	.00020
2.80	112.08	59.404	14.519	.27395	14.535	.27424	.21717	.00410	1.494	.1077	.00025
3.00	106.13	56.247	16.352	.30853	16.369	.30885	.24253	.00458	1.482	.1060	.00031
3.20	100.82	53.436	18.284	.34499	18.304	.34535	.26910	.00508	1.470	.1046	.00038
3.40	96.066	50.915	20.316	.38331	20.337	.38371	.29686	.00560	1.460	.1033	.00046
3.60	91.775	48.641	22.444	.42348	22.467	.42391	.32581	.00615	1.450	.1022	.00071
3.80	87.883	46.578	24.670	.46547	24.695	.46594	.35591	.00672	1.441	.1011	.00277
4.00	84.335	44.698	26.991	.50927	27.018	.50978	.38716	.00730	1.433	.1001	.00481
4.20	81.086	42.976	29.409	.55488	29.438	.55543	.41954	.00792	1.425	.0992	.00684
4.40	78.099	41.392	31.920	.60226	31.951	.60285	.45305	.00855	1.418	.0984	.00886
4.60	75.342	39.932	34.525	.65142	34.559	.65206	.48766	.00920	1.411	.0976	.01088
4.80	72.790	38.579	37.224	.70214	37.260	.70302	.52336	.00987	1.405	.0969	.01288

## LITHIUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	PERCENT		
5.00	70.420	37.323	.04002	.07550	.04005	.07557	.00056	1.398	.0962	.01488
5.50	65.170	34.540	.04740	.08943	.04744	.08951	.00066	1.385	.0948	.01985
6.00	60.706	32.174	.05534	.10442	.05539	.10452	.00076	1.272	.0935	.02478
6.50	56.960	30.136	.06385	.12048	.06391	.12059	.00087	1.361	.0924	.02968
7.00	53.510	28.360	.07291	.13757	.07298	.13770	.00099	1.351	.0914	.03456
7.50	50.564	26.799	.08252	.15570	.08260	.15584	.00111	1.342	.0905	.03940
8.00	47.950	25.414	.09267	.17485	.09276	.17501	.00124	1.333	.0898	.04422
8.50	45.615	24.176	.10336	.19502	.10345	.19519	.00137	1.325	.0890	.04903
9.00	43.516	23.063	.11458	.21618	.11468	.21637	.00151	1.318	.0884	.05381
9.50	41.617	22.057	.12632	.23834	.12643	.23855	.00166	1.311	.0878	.05857
10.00	39.890	21.142	.13858	.26148	.13870	.26171	.00181	1.305	.0873	.06331
11.00	36.866	19.539	.16466	.31068	.16480	.31095	.00213	1.294	.0863	.07275
12.00	34.504	18.181	.19278	.36373	.19294	.36405	.00248	1.284	.0855	.08213
13.00	32.102	17.014	.22291	.42058	.22310	.42094	.00284	1.274	.0848	.09145
14.00	30.189	16.000	.25502	.48118	.25524	.48158	.00323	1.266	.0841	.10072
15.00	28.509	15.110	.28910	.54547	.28934	.54592	.00364	1.258	.0836	.10993
16.00	27.023	14.322	.32511	.61342	.32536	.61393	.00407	1.250	.0830	.11908
17.00	25.697	13.619	.36305	.68499	.36335	.68556	.00452	1.242	.0826	.12819
18.00	24.507	12.988	.40288	.76014	.40321	.76077	.00499	1.239	.0821	.13724
19.00	23.432	12.419	.44459	.83884	.44495	.83953	.00549	1.233	.0817	.14624
20.00	22.456	11.902	.48816	.92105	.48856	.92180	.00600	1.228	.0814	.15519
22.00	20.750	10.998	.58082	1.0959	.58129	1.0968	.00708	1.218	.0807	.17294
24.00	19.308	10.233	.68074	1.2844	.68129	1.2854	.00824	1.209	.0801	.19047
26.00	18.071	9.5778	.78780	1.4864	.78842	1.4876	.00947	1.201	.0796	.20056
28.00	16.999	9.0093	.90188	1.7017	.90260	1.7030	.01078	1.194	.0792	.20315
30.00	16.059	8.5112	1.0229	1.9300	1.0237	1.9315	.01216	1.187	.0787	.20582
32.00	15.228	8.0710	1.1507	2.1712	1.1516	2.1729	.01360	1.181	.0784	.20856
34.00	14.489	7.6790	1.2853	2.4252	1.2863	2.4271	.01512	1.175	.0780	.21137
36.00	13.826	7.3276	1.4266	2.6917	1.4277	2.6938	.01670	1.170	.0777	.21424
38.00	13.228	7.0106	1.5744	2.9706	1.5756	2.9729	.01836	1.165	.0774	.21716
40.00	12.685	6.7232	1.7287	3.2618	1.7301	3.2643	.02007	1.160	.0771	.22011
45.00	11.527	6.1093	2.1425	4.0424	2.1441	4.0455	.02464	1.149	.0765	.22762
50.00	10.566	5.6106	2.5953	4.8968	2.5973	4.9005	.02960	1.140	.0760	.23519
55.00	9.8059	5.1971	3.0861	5.8228	3.0884	5.8272	.03493	1.131	.0756	.24295
60.00	9.1480	4.8485	3.6140	6.8189	3.6167	6.8240	.04061	1.123	.0752	.25104
65.00	8.5855	4.5503	4.1782	7.8833	4.1813	7.8892	.04665	1.116	.0748	.25942
70.00	8.0987	4.2923	4.7777	9.0145	4.7812	9.0212	.05302	1.109	.0745	.26804
75.00	7.6732	4.0668	5.4118	10.211	5.4158	10.218	.05972	1.103	.0742	.27686
80.00	7.2979	3.8679	6.0797	11.471	6.0842	11.480	.06673	1.097	.0740	.28584
90.00	6.6660	3.5330	7.5144	14.178	7.5199	14.188	.09166	1.086	.0735	.30413

## LITHIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	6.1541	9.0762	17.137	.09775	.0731	.32263
110.00	5.7310	10.760	20.317	.1493	.0728	.34158
120.00	5.3751	12.562	23.719	.13315	.0725	.36127
130.00	5.0715	14.477	27.335	.15235	.0722	.38157
140.00	4.8095	16.502	31.135	.17249	.0719	.40234
150.00	4.5811	18.631	35.154	.19351	.0717	.42344
160.00	4.3801	20.863	39.364	.21538	.0715	.44460
170.00	4.2020	23.193	43.761	.23806	.0713	.46553
180.00	4.0429	25.618	48.371	.26151	.0711	.48616
190.00	3.9001	28.136	53.124	.28559	.0710	.50640
200.00	3.7711	30.742	58.045	.31058	.0708	.52620
210.00	3.6541	33.435	63.129	.33615	.0706	.54512
220.00	3.5475	36.211	68.370	.36235	.0705	.56280
230.00	3.4500	39.068	73.774	.38918	.0704	.57923
240.00	3.3604	42.003	79.331	.41660	.0702	.59445
250.00	3.2778	45.014	84.992	.44458	.0701	.60847
260.00	3.2015	48.100	90.818	.47311	.0700	.62171
270.00	3.1308	51.256	96.778	.50216	.0699	.63455
280.00	3.0651	54.483	102.77	.53172	.0697	.64699
290.00	3.0040	57.776	109.09	.56176	.0696	.65902
300.00	2.9468	61.135	115.43	.59226	.0695	.67064
310.00	2.8934	64.558	121.89	.62321	.0694	.68232
320.00	2.8433	68.043	128.47	.65459	.0693	.69449
330.00	2.7962	71.587	135.16	.68638	.0692	.70707
340.00	2.7519	75.190	141.87	.71858	.0691	.72000
350.00	2.7102	78.849	148.77	.75115	.0690	.73319
360.00	2.6708	82.564	155.89	.78410	.0689	.74640
370.00	2.6336	86.332	162.89	.81741	.0688	.75942
380.00	2.5984	90.152	170.10	.85106	.0688	.77222
390.00	2.5650	94.023	177.40	.88504	.0687	.78476
400.00	2.5334	97.944	184.80	.91934	.0686	.79701
410.00	2.5033	101.91	192.29	.95396	.0685	.80880
420.00	2.4747	105.93	199.86	.98888	.0684	.82001
430.00	2.4475	109.99	207.52	1.0241	.0683	.83065
440.00	2.4216	114.09	215.27	1.0596	.0682	.84074
450.00	2.3968	118.24	223.10	1.0953	.0681	.85030
460.00	2.3732	122.43	231.00	1.1313	.0681	.85936
470.00	2.3507	126.66	238.99	1.1676	.0680	.86792
480.00	2.3291	130.93	247.05	1.2041	.0679	.87602
490.00	2.3084	135.24	255.18	1.2409	.0678	.88367

# LITHIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CH2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.2887	139.59	139.69	263.56	1.2779	2.4111	.0677	.89089
510.00	2.2697	143.98	144.07	271.94	1.3151	2.4814	.0677	.89770
520.00	2.2516	148.40	148.50	280.18	1.3526	2.5520	.0676	.90411
530.00	2.2331	152.85	152.96	288.60	1.3902	2.6231	.0675	.91016
540.00	2.2162	157.34	157.45	297.07	1.4281	2.6946	.0674	.91506
550.00	2.2000	161.88	161.99	305.64	1.4662	2.7665	.0673	.92122
560.00	2.1844	166.44	166.55	314.24	1.5046	2.8388	.0673	.92626
570.00	2.1694	171.03	171.14	322.91	1.5431	2.9114	.0672	.93099
580.00	2.1550	175.65	175.77	331.63	1.5817	2.9844	.0671	.93544
590.00	2.1411	180.30	180.42	340.41	1.6206	3.0578	.0670	.93962
600.00	2.1277	184.98	185.10	349.25	1.6597	3.1315	.0670	.94354
620.00	2.1022	194.43	194.56	367.09	1.7383	3.2798	.0668	.95068
640.00	2.0785	203.99	204.12	385.14	1.8176	3.4294	.0667	.95694
660.00	2.0564	213.65	213.79	403.38	1.8975	3.5802	.0665	.96244
680.00	2.0357	223.41	223.56	421.82	1.9780	3.7321	.0664	.96726
700.00	2.0163	233.31	233.46	440.50	2.0591	3.8851	.0662	.97148
720.00	1.9982	243.27	243.43	459.30	2.1407	4.0391	.0661	.97516
740.00	1.9811	253.31	253.48	478.26	2.2229	4.1941	.0659	.97838
760.00	1.9651	263.44	263.62	497.39	2.3055	4.3501	.0658	.98119
780.00	1.9499	273.66	273.83	516.67	2.3887	4.5069	.0657	.98364
800.00	1.9357	283.94	284.13	536.09	2.4723	4.6647	.0655	.98578
820.00	1.9223	294.31	294.50	555.66	2.5563	4.8233	.0654	.98763
840.00	1.9096	304.74	304.94	575.36	2.6408	4.9827	.0652	.98925
860.00	1.8976	315.24	315.45	595.19	2.7257	5.1429	.0651	.99066
880.00	1.8862	325.81	326.02	615.14	2.8110	5.3038	.0649	.99188
900.00	1.8754	336.44	336.66	635.21	2.8967	5.4654	.0648	.99294
920.00	1.8653	347.14	347.36	655.40	2.9827	5.6278	.0647	.99387
940.00	1.8556	357.89	358.12	675.71	3.0691	5.7908	.0645	.99467
960.00	1.8464	368.71	368.95	696.13	3.1559	5.9545	.0643	.99537
1000.00	1.8294	390.59	390.84	737.43	3.3304	6.2838	.0639	.99650

THE ELECTRON DENSITY OF LITHIUM IS 2.605E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.398 BEV, AND THE MINIMUM ENERGY LOSS IS 1.6594 MEV/GM/CH2

## MAGNESIUM

ATOMIC NUMBER 12  
 ELEMENT HG  
 ATOMS/MOLECULE 1  
 ADJUSTED IONIZATION POTENTIAL 156.5  
 ATOMIC WEIGHT 24.312

DENSITY = 1.7400 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS MEV/GM/CM2	PROTON RANGE MG/CM2	PROTON PATH LENGTH HG/CM2	PROTON PATH LENGTH MM	PATH LENGTH STRAGGLING HG/CM2	PATH LENGTH STRAGGLING MM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	423.98	.25314	.00145	.00147	.00968	.00006	1.231	0.
.15	393.92	.37512	.00216	.00218	.01357	.00008	.9233	0.
.20	368.88	.50559	.00291	.00293	.01701	.00010	.8193	0.
.30	325.28	.79237	.00455	.00459	.02352	.00014	.7357	0.
.40	290.58	1.1161	.00641	.00646	.03019	.00017	.6911	0.
.50	262.67	1.4763	.00848	.00854	.03722	.00021	.6580	0.
.60	238.71	1.8737	.01077	.01084	.04476	.00026	.6307	0.
.70	218.98	2.3088	.01327	.01335	.05308	.00031	.6075	0.
.80	202.66	2.7812	.01598	.01608	.06227	.00036	.5874	0.
.90	192.61	3.2845	.01888	.01898	.07194	.00041	.5700	0.
1.00	182.55	3.8156	.02193	.02205	.08186	.00047	.5545	0.
1.20	162.44	4.9752	.02859	.02875	.10342	.00059	.5201	0.
1.40	146.75	6.2675	.03602	.03620	.12717	.00073	.5060	0.
1.60	134.14	7.6883	.04419	.04440	.15300	.00088	.4879	0.
1.80	123.79	9.2410	.05311	.05336	.18073	.00104	.4724	.00001
2.00	115.03	10.907	.06268	.06297	.21029	.00121	.4592	.00001
2.20	107.60	12.700	.07299	.07331	.24157	.00139	.4477	.00002
2.40	101.20	14.612	.08398	.08435	.27450	.00158	.4377	.00003
2.60	95.624	16.640	.09563	.09604	.30900	.00178	.4289	.00003
2.80	90.702	18.780	.10793	.10839	.34503	.00198	.4210	.00005
3.00	86.321	21.032	.12087	.12137	.38255	.00220	.4140	.00006
3.20	82.392	23.395	.13445	.13500	.42153	.00242	.4077	.00007
3.40	78.847	25.867	.14866	.14926	.46194	.00265	.4020	.00008
3.60	75.631	28.449	.16350	.16415	.50376	.00290	.3966	.00010
3.80	72.699	31.141	.17897	.17968	.54697	.00314	.3919	.00012
4.00	70.013	33.933	.19502	.19577	.59153	.00340	.3874	.00014
4.20	67.543	36.833	.21169	.21250	.63743	.00366	.3833	.00016
4.40	65.263	39.837	.22895	.22982	.68466	.00393	.3795	.00018
4.60	63.150	42.939	.24678	.24771	.73318	.00421	.3759	.00020
4.80	61.350	46.145	.26520	.26619	.78261	.00450	.3726	.00023

## MAGNESIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	CM	GM/CH2	PATH LENGTH STRAGGLING CM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
3.00	59.508	103.54	.04943	.02541	.04962	.02852	.00083	.00048	.00026
5.50	55.407	96.402	.05812	.03340	.05834	.03353	.00097	.00055	.00033
6.00	51.895	90.297	.06743	.03875	.06767	.03889	.00111	.00064	.00042
6.50	48.848	84.996	.07733	.04444	.07760	.04460	.00125	.00072	.00052
7.00	46.177	80.347	.08783	.05048	.08814	.05065	.00141	.00081	.00064
7.50	43.813	76.234	.09892	.05685	.09926	.05704	.00157	.00090	.00077
8.00	41.704	72.546	.11058	.06355	.11095	.06377	.00174	.00100	.00180
8.50	39.811	69.271	.12261	.07098	.12322	.07082	.00192	.00110	.00327
9.00	38.100	66.293	.13563	.07795	.13608	.07821	.00210	.00121	.00504
9.50	36.545	63.588	.14899	.08562	.14948	.08591	.00229	.00132	.00690
10.00	35.125	61.118	.16290	.09362	.16343	.09393	.00249	.00143	.00875
11.00	32.625	56.767	.19238	.11056	.19300	.11092	.00290	.00167	.01247
12.00	30.490	53.053	.22401	.12774	.22473	.12915	.00334	.00192	.01620
13.00	28.645	49.842	.25776	.148.5	.25859	.14861	.00380	.00218	.01995
14.00	27.032	47.035	.29362	.16875	.29454	.16927	.00429	.00247	.02370
15.00	25.609	44.559	.33154	.19054	.33256	.19113	.00480	.00276	.02748
16.00	24.343	42.357	.37149	.21350	.37262	.21415	.00534	.00307	.03126
17.00	23.198	40.365	.41346	.23762	.41472	.23834	.00590	.00339	.03507
18.00	22.179	38.592	.45743	.26299	.45891	.26368	.00648	.00373	.03889
19.00	21.255	36.984	.50336	.28930	.50488	.29016	.00709	.00407	.04272
20.00	20.414	35.520	.55127	.31882	.55291	.31777	.00772	.00444	.04657
22.00	18.935	32.948	.65279	.37517	.65471	.37627	.00904	.00520	.05430
24.00	17.676	30.760	.76188	.43786	.76410	.43914	.01045	.00600	.06210
26.00	16.595	28.876	.87839	.50482	.88093	.50628	.01194	.00686	.06698
28.00	15.652	27.234	1.0022	.57599	1.0051	.57764	.01351	.00777	.06885
30.00	14.822	25.790	1.1332	.65128	1.1365	.65313	.01517	.00872	.07079
32.00	14.086	24.509	1.2713	.73055	1.2749	.73271	.01690	.00971	.07281
34.00	13.428	23.365	1.4164	.81403	1.4204	.81632	.01871	.01075	.07489
36.00	12.837	22.337	1.5684	.90158	1.5728	.90390	.02059	.01183	.07704
38.00	12.303	21.407	1.7272	.99262	1.7320	.99538	.02255	.01296	.07924
40.00	11.817	20.561	1.8926	1.0877	1.8979	1.0907	.02458	.01412	.08149
45.00	10.775	18.749	2.3352	1.3420	2.3416	1.3457	.02996	.01722	.08731
50.00	9.9253	17.270	2.8179	1.6195	2.8255	1.6239	.03577	.02056	.09336
55.00	9.2177	16.039	3.3397	1.9194	3.3487	1.9246	.04199	.02413	.09966
60.00	8.6191	14.997	3.8996	2.2412	3.9101	2.2472	.04861	.02793	.10626
65.00	8.1056	14.104	4.4966	2.5843	4.5086	2.5912	.05560	.03196	.11311
70.00	7.6600	13.328	5.1299	2.9482	5.1435	2.9560	.06297	.03619	.12019
75.00	7.2696	12.649	5.7985	3.3325	5.8138	3.3413	.07069	.04063	.12746
80.00	6.9246	12.049	6.5017	3.7366	6.5188	3.7465	.07876	.04526	.13490
90.00	6.3420	11.035	8.1088	4.6028	8.0298	4.6148	.09588	.05510	.15016



## MAGNESIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
100.00	5.8686	10.211	5.5434	9.6706	5.5578	.11426	.06567	1.182	.16579
110.00	5.4762	9.5285	6.3555	11.436	6.5724	.13383	.07691	1.170	.18177
120.00	5.1453	8.9528	7.6362	13.321	7.6559	.15452	.08881	1.160	.19815
130.00	4.8625	8.4608	8.7830	15.282	8.8055	.17627	.10131	1.150	.21480
140.00	4.6186	8.0354	9.9934	17.389	10.019	.19903	.11439	1.142	.23163
150.00	4.4045	7.6638	11.265	19.601	11.294	.22275	.12802	1.134	.24853
160.00	4.2163	7.3364	12.596	21.917	12.628	.24737	.14217	1.126	.26554
170.00	4.0493	7.0459	13.984	24.332	14.019	.27286	.15682	1.119	.28271
180.00	3.9001	6.7862	15.427	26.843	15.466	.29918	.17194	1.112	.29996
190.00	3.7660	6.5528	16.923	29.446	16.966	.32628	.18752	1.105	.31725
200.00	3.6447	6.3418	18.471	32.139	18.517	.35413	.20352	1.099	.33450
210.00	3.5346	6.1503	20.069	34.919	20.119	.38269	.21994	1.093	.35175
220.00	3.4342	5.9756	21.714	37.783	21.769	.41195	.23675	1.088	.36999
230.00	3.3423	5.8156	23.407	40.728	23.465	.44185	.25394	1.082	.38820
240.00	3.2578	5.6687	25.145	43.752	25.207	.47239	.27149	1.077	.40362
250.00	3.1800	5.5332	26.926	46.851	26.993	.50352	.28938	1.072	.42032
260.00	3.1080	5.4079	28.750	50.025	28.821	.53523	.30760	1.067	.43720
270.00	3.0412	5.2917	30.615	53.270	30.691	.56748	.32614	1.063	.45391
280.00	2.9792	5.1838	32.520	56.584	32.600	.60027	.34498	1.058	.47045
290.00	2.9213	5.0831	34.463	59.966	34.549	.63355	.36412	1.054	.48679
300.00	2.8673	4.9892	36.445	63.413	36.535	.66734	.38353	1.050	.50290
310.00	2.8168	4.9012	38.462	66.924	38.557	.70159	.40321	1.046	.51878
320.00	2.7694	4.8188	40.515	70.496	40.615	.73629	.42315	1.042	.53444
330.00	2.7249	4.7413	42.602	74.128	42.707	.77141	.44334	1.038	.54986
340.00	2.6830	4.6685	44.723	77.818	44.833	.80696	.46377	1.034	.56502
350.00	2.6435	4.5998	46.876	81.584	46.991	.84290	.48442	1.031	.57991
360.00	2.6063	4.5349	49.060	85.364	49.181	.87923	.50530	1.027	.59452
370.00	2.5711	4.4737	51.275	89.218	51.401	.91592	.52639	1.024	.60887
380.00	2.5378	4.4157	53.520	93.124	53.651	.95297	.54769	1.021	.62294
390.00	2.5062	4.3607	55.793	97.080	55.930	.99037	.56918	1.018	.63671
400.00	2.4762	4.3086	58.095	101.09	58.237	1.0281	.59086	1.015	.65019
410.00	2.4477	4.2591	60.424	105.39	60.571	1.0661	.61273	1.012	.66333
420.00	2.4207	4.2120	62.779	109.50	62.933	1.1045	.63477	1.009	.67612
430.00	2.3949	4.1672	65.161	113.38	65.320	1.1431	.65698	1.006	.68855
440.00	2.3704	4.1245	67.567	117.57	67.732	1.1821	.67936	1.003	.70063
450.00	2.3470	4.0838	69.998	121.80	70.168	1.2213	.70190	1.000	.71235
460.00	2.3246	4.0449	72.453	126.07	72.629	1.2608	.72459	.9977	.72372
470.00	2.3033	4.0078	74.931	130.38	75.113	1.3005	.74743	.9951	.73473
480.00	2.2829	3.9722	77.431	134.73	77.619	1.3405	.77041	.9926	.74540
490.00	2.2634	3.9383	79.954	139.12	80.147	1.3807	.79353	.9901	.75572

# MAGNESIUM

PRCTCN ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	CH	GM/CM2	CM	PATH LENGTH STRAGGLING GM/CM2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.2447	3.9050	143.55	82.497	143.89	82.697	1.4212	.81679	.9877	.76571
510.00	2.2268	3.3743	148.01	85.062	148.37	85.268	1.4619	.84018	.9853	.77536
520.00	2.2096	3.0447	152.51	87.647	152.87	87.859	1.5028	.86369	.9830	.78468
530.00	2.1931	3.8160	157.04	90.252	157.42	90.470	1.5439	.88732	.9808	.79368
540.00	2.1773	3.7885	161.60	92.876	161.99	93.100	1.5853	.91107	.9786	.80237
550.00	2.1621	3.7621	166.20	95.518	166.60	95.749	1.6268	.93494	.9765	.81074
560.00	2.1475	3.7367	170.83	98.179	171.24	98.416	1.6685	.95892	.9744	.81881
570.00	2.1335	3.7122	175.49	100.86	175.92	101.10	1.7104	.98300	.9723	.82659
580.00	2.1199	3.6887	180.18	103.55	180.62	103.80	1.7525	1.0072	.9703	.83408
590.00	2.1069	3.6661	184.90	106.27	185.35	106.52	1.7948	1.0315	.9683	.84128
600.00	2.0944	3.6443	189.65	109.00	190.11	109.26	1.8372	1.0559	.9664	.84822
620.00	2.0707	3.6030	199.24	114.50	199.71	114.78	1.9226	1.1049	.9627	.86129
640.00	2.0486	3.5646	208.93	120.07	209.43	120.36	2.0086	1.1543	.9591	.87336
660.00	2.0281	3.5288	218.72	125.70	219.24	126.00	2.0951	1.2041	.9556	.88448
680.00	2.0089	3.4955	228.60	131.38	229.15	131.69	2.1823	1.2542	.9523	.89472
700.00	1.9910	3.4643	238.58	137.12	239.15	137.44	2.2699	1.3046	.9492	.90412
720.00	1.9742	3.4351	248.65	142.90	249.24	143.24	2.3581	1.3552	.9463	.91276
740.00	1.9585	3.4077	258.79	148.73	259.41	149.09	2.4467	1.4062	.9432	.92067
760.00	1.9437	3.3821	269.02	154.61	269.66	154.98	2.5358	1.4574	.9404	.92792
780.00	1.9299	3.3580	279.33	160.53	279.99	160.91	2.6253	1.5088	.9377	.93454
800.00	1.9169	3.3353	289.70	166.50	290.39	166.89	2.7153	1.5605	.9351	.94060
820.00	1.9046	3.3140	300.15	172.50	300.86	172.91	2.8056	1.6124	.9325	.94612
840.00	1.8931	3.2940	310.66	178.54	311.39	178.96	2.8963	1.6645	.9301	.95116
860.00	1.8822	3.2750	321.23	184.62	321.99	185.05	2.9873	1.7168	.9278	.95576
880.00	1.8720	3.2572	331.87	190.73	332.65	191.18	3.0787	1.7694	.9255	.95994
900.00	1.8623	3.2404	342.56	196.87	343.36	197.33	3.1704	1.8221	.9233	.96374
920.00	1.8531	3.2244	353.31	203.05	354.14	203.53	3.2624	1.8749	.9212	.96719
940.00	1.8445	3.2094	364.12	209.26	364.97	209.75	3.3547	1.9280	.9192	.97033
960.00	1.8363	3.1951	374.98	215.51	375.86	216.01	3.4473	1.9812	.9172	.97319
1000.00	1.8211	3.1688	396.96	228.14	397.88	228.67	3.6333	2.0881	.9132	.97813

THE ELECTRON DENSITY OF MAGNESIUM IS 2.974E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.188 BEV, AND THE MINIMUM ENERGY LOSS IS 1.6887 MEV/GM/CM2

# MANGANESE

ATOMIC  
NUMBER  
25  
ELEMENT  
MN  
ATOMS/  
MOLECULE  
1.  
ATOMIC  
WEIGHT  
54.938  
ADJUSTED  
IONIZATION  
POTENTIAL  
253.0

DENSITY = 7.4300 GM/CM3

PRCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	MEV/CM2	MEV/CM	MG/CM2	MM	MG/CM2	MM	MG/CM2	MM			
.10	337.51	2507.7	.45249	.00061	.46253	.00062	.01984	.00003	4.290	2.172	0.
.15	313.72	2330.9	.60542	.00081	.61616	.00083	.02339	.00003	3.796	1.743	0.
.20	294.83	2190.6	.76837	.00103	.78054	.00105	.02698	.00004	3.457	1.559	0.
.30	257.72	1914.9	1.1270	.00152	1.1429	.00154	.03452	.00005	3.021	1.386	0.
.40	221.75	1647.6	1.5412	.00207	1.5614	.00210	.04383	.00006	2.807	1.291	0.
.50	194.78	1447.2	2.0187	.00272	2.0438	.00275	.05574	.00008	2.727	1.226	0.
.60	176.73	1313.1	2.5531	.00344	2.5836	.00348	.06924	.00009	2.680	1.177	0.
.70	160.11	1189.6	3.1413	.00423	3.1775	.00428	.08395	.00011	2.642	1.138	0.
.80	151.71	1127.2	3.7841	.00509	3.8264	.00515	.09976	.00013	2.607	1.106	0.
.90	143.39	1065.4	4.4546	.00600	4.5033	.00606	.11512	.00015	2.556	1.050	0.
1.00	135.06	1003.5	5.1675	.00695	5.2227	.00703	.13093	.00018	2.507	1.056	0.
1.20	120.91	898.37	6.7211	.00905	6.7900	.00914	.16469	.00022	2.426	1.015	0.
1.40	109.92	816.70	8.4437	.01136	8.5273	.01148	.20105	.00027	2.358	.9808	0.
1.60	101.08	751.04	10.328	.01390	10.427	.01403	.23975	.00032	2.299	.9519	0.
1.80	93.828	697.14	12.366	.01664	12.482	.01680	.28059	.00038	2.246	.9274	0.
2.00	87.770	652.13	14.555	.01959	14.688	.01977	.32340	.00044	2.202	.9059	0.
2.20	82.609	613.78	16.887	.02273	17.038	.02293	.36804	.00050	2.160	.8871	0.
2.40	78.096	580.25	19.359	.02606	19.529	.02628	.41445	.00056	2.122	.8704	0.
2.60	74.128	550.77	21.969	.02957	22.158	.02982	.46262	.00062	2.088	.8554	0.
2.80	70.603	524.58	24.715	.03326	24.925	.03355	.51250	.00069	2.056	.8417	0.
3.00	67.444	501.11	27.593	.03714	27.824	.03745	.56409	.00076	2.027	.8294	0.
3.20	64.591	479.91	30.602	.04119	30.855	.04153	.61757	.00083	2.002	.8179	0.
3.40	62.000	460.66	33.742	.04541	34.016	.04578	.67321	.00091	1.979	.8076	.00001
3.60	59.634	443.08	37.008	.04981	37.305	.05021	.73090	.00098	1.959	.7978	.00001
3.80	57.463	426.95	40.402	.05438	40.723	.05481	.79056	.00106	1.941	.7889	.00001
4.00	55.464	412.10	43.921	.05911	44.266	.05958	.85213	.00115	1.925	.7805	.00001
4.20	53.613	398.34	47.566	.06402	47.936	.06452	.91556	.00123	1.910	.7728	.00002
4.40	51.901	385.63	51.331	.06909	51.727	.06962	.98079	.00132	1.896	.7655	.00002
4.60	50.310	373.81	55.220	.07432	55.642	.07489	1.0478	.00141	1.883	.7586	.00003
4.80	48.828	362.79	59.228	.07971	59.677	.08032	1.1164	.00150	1.871	.7522	.00003

MANGANESE

PROCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GM/CH2	MEV/CM	GM/CH2	CM	GM/CH2	CM	GM/CH2	CM			
5.00	47.443	352.50	.06336	.00853	.06383	.00859	.00119	.00016	1.859	.746C	.00004
5.50	44.345	329.49	.07419	.00999	.07474	.01006	.00137	.00018	1.833	.7222	.00006
6.00	41.673	309.63	.08576	.01154	.08638	.01163	.00156	.00021	1.809	.7201	.00009
6.50	39.331	292.23	.09803	.01319	.09873	.01329	.00176	.00024	1.787	.7093	.00012
7.00	37.262	276.86	.11102	.01494	.11180	.01505	.00198	.00027	1.768	.6996	.00016
7.50	35.454	263.42	.12470	.01678	.12557	.01690	.00220	.00030	1.749	.6909	.00021
8.00	33.801	251.14	.13906	.01872	.14001	.01884	.00243	.00033	1.733	.6829	.00027
8.50	32.344	240.31	.15410	.02074	.15515	.02088	.00266	.00036	1.717	.6757	.00033
9.00	31.020	230.48	.16979	.02285	.17094	.02301	.00291	.00039	1.702	.6690	.00040
9.50	29.812	221.50	.18614	.02505	.18738	.02522	.00316	.00043	1.689	.6630	.00048
10.00	28.706	213.28	.20313	.02734	.20447	.02752	.00343	.00046	1.676	.6573	.00056
11.00	26.748	198.74	.23903	.03217	.24058	.03238	.00397	.00053	1.652	.6472	.00075
12.00	25.067	186.25	.27745	.03734	.27924	.03758	.00455	.00061	1.630	.6382	.00104
13.00	23.606	175.40	.31835	.04285	.32037	.04312	.00516	.00069	1.611	.6304	.00029
14.00	22.324	165.87	.36167	.04868	.36393	.04898	.00580	.00078	1.593	.6234	.00431
15.00	21.189	157.43	.40741	.05483	.40994	.05517	.00647	.00087	1.577	.6170	.00678
16.00	20.176	149.31	.45552	.06131	.45832	.06169	.00716	.00096	1.563	.6113	.00927
17.00	19.267	143.15	.50598	.06810	.50906	.06851	.00789	.00106	1.549	.6061	.01178
18.00	18.446	137.05	.55875	.07520	.56213	.07566	.00864	.00116	1.537	.6013	.01432
19.00	17.700	131.51	.61379	.08261	.61747	.08311	.00942	.00127	1.525	.5969	.01687
20.00	17.019	126.45	.67111	.09032	.67511	.09086	.01022	.00138	1.514	.5929	.01944
22.00	15.820	117.55	.79242	.10665	.79709	.10728	.01191	.00160	1.495	.5856	.02463
24.00	14.799	109.95	.92251	.12416	.92789	.12488	.01371	.00184	1.477	.5793	.02990
26.00	13.916	103.40	1.0612	.14283	1.0673	.14365	.01560	.00210	1.461	.5737	.03336
28.00	13.146	97.672	1.2084	.16263	1.2153	.16356	.01759	.00237	1.447	.5688	.03623
30.00	12.466	92.625	1.3638	.18356	1.3716	.18460	.01967	.00265	1.434	.5644	.03658
32.00	11.862	88.135	1.5275	.20558	1.5361	.20674	.02185	.00294	1.422	.5604	.03828
34.00	11.322	84.124	1.6992	.22870	1.7087	.22998	.02412	.00325	1.411	.5568	.04005
36.00	10.836	80.511	1.8789	.25288	1.8893	.25429	.02647	.00356	1.401	.5535	.04188
38.00	10.396	77.239	2.0664	.27812	2.0778	.27965	.02892	.00389	1.392	.5504	.04377
40.00	9.946	74.260	2.2616	.30439	2.2741	.30607	.03145	.00423	1.383	.5476	.04570
45.00	9.1331	67.859	2.7829	.37455	2.7981	.37659	.03814	.00513	1.363	.5415	.05376
50.00	8.4279	62.619	3.3505	.45094	3.3686	.45337	.04533	.00610	1.346	.5364	.06509
55.00	7.8393	58.246	3.9630	.53338	3.9842	.53623	.05301	.00713	1.330	.5320	.06169
60.00	7.3401	54.537	4.6193	.62170	4.6436	.62500	.06115	.00823	1.317	.5283	.06754
65.00	6.9111	51.350	5.3181	.71577	5.3462	.71954	.06974	.00939	1.305	.5250	.07363
70.00	6.5380	48.577	6.0586	.81543	6.0904	.81971	.07877	.01060	1.293	.5220	.07993
75.00	6.2103	46.143	6.8397	.92056	6.8755	.92536	.08821	.01187	1.283	.5195	.08641
80.00	5.9209	43.992	7.6604	1.0310	7.7002	1.0364	.09807	.01320	1.274	.5171	.09305
90.00	5.4312	40.354	9.4574	1.2675	9.4659	1.2740	.11893	.01601	1.256	.5132	.10673

## MANGANESE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
100.00	5.0324	11.323	1.5239	11.381	1.5317	.14127	.01901	.5098	.12077
110.00	4.7011	13.370	1.7995	13.438	1.8086	.16500	.02221	.5071	.13526
120.00	4.4214	15.554	2.0934	15.633	2.1041	.19004	.02558	.5047	.15026
130.00	4.1820	17.870	2.4051	17.960	2.4172	.21633	.02912	.5026	.16569
140.00	3.9748	20.312	2.7337	20.414	2.7475	.24379	.03281	.5006	.18147
150.00	3.7936	22.815	3.0788	22.990	3.0942	.27238	.03666	.4992	.19752
160.00	3.6338	25.557	3.4397	25.685	3.4569	.30202	.04065	.4977	.21382
170.00	3.4919	28.351	3.8158	28.493	3.8348	.33267	.04477	.4965	.23036
180.00	3.3650	31.255	4.2066	31.411	4.2276	.36429	.04903	.4953	.24710
190.00	3.2508	34.265	4.6117	34.435	4.6346	.39682	.05341	.4942	.26397
200.00	3.1476	37.377	5.0305	37.562	5.0555	.43023	.05790	.4933	.28092
210.00	3.0538	40.587	5.4626	40.788	5.4897	.46447	.06251	.4924	.29791
220.00	2.9682	43.894	5.9076	44.110	5.9368	.49950	.06723	.4916	.31492
230.00	2.8898	47.292	6.3650	47.525	6.3964	.53530	.07205	.4908	.33190
240.00	2.8178	50.780	6.8345	51.030	6.8681	.57182	.07696	.4901	.34881
250.00	2.7513	54.355	7.3156	54.622	7.3516	.60904	.08197	.4894	.36552
260.00	2.6899	58.014	7.8080	58.299	7.8464	.64693	.08707	.4886	.38234
270.00	2.6329	61.754	8.3114	62.057	8.3522	.68546	.09226	.4882	.39896
280.00	2.5799	65.573	8.8254	65.894	8.8687	.72459	.09752	.4877	.41546
290.00	2.5305	69.468	9.3497	69.808	9.3955	.76432	.10287	.4871	.43181
300.00	2.4843	73.438	9.8840	73.797	9.9323	.80460	.10829	.4866	.44799
310.00	2.4411	77.480	10.428	77.858	10.479	.84543	.11379	.4862	.46398
320.00	2.4006	81.591	10.981	81.989	11.035	.88677	.11935	.4857	.47974
330.00	2.3626	85.770	11.544	86.169	11.600	.92862	.12498	.4852	.49528
340.00	2.3268	90.015	12.115	90.454	12.174	.97094	.13068	.4848	.51056
350.00	2.2930	94.324	12.695	94.783	12.757	1.0137	.13644	.4844	.52558
360.00	2.2612	98.695	13.283	99.175	13.348	1.0569	.14225	.4840	.54037
370.00	2.2311	103.13	13.880	103.63	13.947	1.1006	.14813	.4836	.55496
380.00	2.2026	107.62	14.484	108.14	14.554	1.1446	.15406	.4832	.56933
390.00	2.1756	112.16	15.096	112.71	15.169	1.1891	.16004	.4828	.58348
400.00	2.1500	116.77	15.715	117.33	15.792	1.2339	.16607	.4825	.59738
410.00	2.1256	121.42	16.342	122.01	16.421	1.2791	.17216	.4821	.61101
420.00	2.1025	126.13	16.976	126.74	17.058	1.3247	.17829	.4817	.62432
430.00	2.0804	130.89	17.616	131.52	17.701	1.3706	.18446	.4814	.63731
440.00	2.0595	135.70	18.263	136.35	18.352	1.4168	.19068	.4810	.64999
450.00	2.0394	140.55	18.917	141.23	19.008	1.4633	.19695	.4807	.66235
460.00	2.0203	145.46	19.577	146.16	19.671	1.5102	.20325	.4804	.67438
470.00	2.0021	150.41	20.243	151.13	20.341	1.5573	.20959	.4800	.68610
480.00	1.9846	155.40	20.915	156.15	21.016	1.6047	.21598	.4797	.69749
490.00	1.9679	160.44	21.593	161.31	21.697	1.6524	.22240	.4794	.70857

# MANGANESE

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	MEV/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM			
500.00	1.9520	14.503	165.51	22.276	166.31	22.384	1.7004	.22885	1.022	.4790	.71933
510.00	1.9367	14.389	170.63	22.965	171.45	23.076	1.7486	.23534	1.020	.4787	.72978
520.00	1.9220	14.280	175.79	23.660	176.64	23.774	1.7970	.24186	1.017	.4784	.73992
530.00	1.9079	14.176	180.99	24.359	181.86	24.476	1.8457	.24842	1.015	.4781	.74975
540.00	1.8944	14.075	186.23	25.064	187.12	25.184	1.8947	.25500	1.013	.4778	.75928
550.00	1.8814	13.979	191.50	25.774	192.42	25.897	1.9439	.26162	1.010	.4774	.76851
560.00	1.8689	13.886	196.81	26.488	197.75	26.615	1.9932	.26827	1.008	.4771	.77745
570.00	1.8569	13.797	202.15	27.207	203.12	27.338	2.0428	.27494	1.006	.4768	.78610
580.00	1.8454	13.711	207.53	27.931	208.52	28.065	2.0926	.28164	1.004	.4765	.79446
590.00	1.8342	13.628	212.94	28.659	213.96	28.796	2.1426	.28837	1.001	.4762	.80255
600.00	1.8235	13.549	218.38	29.392	219.42	29.532	2.1928	.29513	.9993	.4759	.81037
620.00	1.8033	13.399	229.36	30.869	230.45	31.017	2.2937	.30671	.9953	.4752	.82522
640.00	1.7845	13.259	240.46	32.363	241.60	32.517	2.3954	.32239	.9914	.4746	.83905
660.00	1.7669	13.128	251.67	33.872	252.87	34.033	2.4977	.33616	.9877	.4740	.85192
680.00	1.7506	13.007	262.99	35.396	264.24	35.564	2.6006	.35001	.9842	.4733	.86387
700.00	1.7353	12.893	274.41	36.933	275.72	37.108	2.7041	.36394	.9807	.4727	.87496
720.00	1.7210	12.787	285.93	38.484	287.29	38.666	2.8081	.37795	.9775	.4721	.88524
740.00	1.7076	12.688	297.55	40.047	298.96	40.236	2.9127	.39202	.9743	.4714	.89474
760.00	1.6951	12.594	309.25	41.622	310.71	41.819	3.0178	.40617	.9713	.4708	.90353
780.00	1.6833	12.507	321.04	43.208	322.55	43.412	3.1234	.42037	.9683	.4701	.91164
800.00	1.6722	12.424	332.91	44.806	334.48	45.017	3.2294	.43464	.9655	.4695	.91912
820.00	1.6618	12.347	344.85	46.413	346.48	46.632	3.3358	.44897	.9628	.4688	.92601
840.00	1.6520	12.274	356.87	48.031	358.55	48.257	3.4427	.46335	.9602	.4682	.93235
860.00	1.6428	12.206	368.96	49.658	370.69	49.891	3.5499	.47778	.9576	.4675	.93819
880.00	1.6341	12.141	381.11	51.294	382.90	51.535	3.6575	.49226	.9552	.4668	.94355
900.00	1.6259	12.080	393.34	52.939	395.18	53.187	3.7655	.50679	.9529	.4662	.94847
920.00	1.6181	12.023	405.62	54.592	407.52	54.848	3.8738	.52137	.9506	.4655	.95299
940.00	1.6108	11.968	417.97	56.254	419.92	56.517	3.9824	.53593	.9484	.4647	.95713
960.00	1.6039	11.917	430.39	57.926	432.39	58.196	4.0913	.55065	.9462	.4639	.96092
1000.00	1.5912	11.823	455.51	61.306	457.62	61.591	4.3101	.58002	.9419	.4616	.96757

THE ELECTRON DENSITY OF MANGANESE IS 2.742E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.112 BEV, AND THE MINIMUM ENERGY LOSS IS 1.4900 MEV/GM/CM2

MOLYBDENUM

ADJUSTED  
IONIZATION  
POTENTIAL  
420.0

ATOMIC  
WEIGHT  
95.940

ATOMS/  
MOLECULE  
1

ATOMIC  
NUMBER  
42

ELEMENT  
MO

DENSITY = 10.200 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM <sup>2</sup>	PROTON RANGE MG/CM <sup>2</sup>	PROTON PATH LENGTH MM MG/CM <sup>2</sup>	PATH LENGTH STRAGGLING MM MG/CM <sup>2</sup>	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	267.17	.70846	.73222	.00072	.03407	3.245
.15	235.90	.90619	.93126	.00091	.03789	2.692
.20	211.46	1.1270	1.1550	.00113	.04288	2.429
.30	176.80	1.6373	1.6741	.00164	.05737	2.195
.40	154.19	2.2337	2.2814	.00224	.07549	2.091
.50	138.41	2.9068	2.9670	.00291	.09560	2.028
.60	126.34	3.6500	3.7238	.00365	.11702	1.982
.70	116.38	4.4605	4.5490	.00446	.13959	1.944
.80	109.06	5.3340	5.4379	.00533	.16306	1.910
.90	102.47	6.2632	6.3832	.00626	.18711	1.880
1.00	95.878	7.2554	7.3924	.00725	.21228	1.852
1.20	87.335	9.4081	9.5808	.00939	.26505	1.803
1.40	80.574	11.757	11.968	.01173	.32052	1.759
1.60	75.011	14.293	14.543	.01426	.37985	1.721
1.80	70.404	17.005	17.296	.01696	.44219	1.685
2.00	66.356	19.890	20.224	.01983	.50728	1.653
2.20	62.821	22.944	23.323	.02287	.57494	1.624
2.40	59.722	26.163	26.588	.02607	.64502	1.597
2.60	56.971	29.548	30.019	.02943	.71737	1.572
2.80	54.511	33.088	33.609	.03295	.79289	1.549
3.00	52.293	36.787	37.357	.03662	.86848	1.527
3.20	50.279	40.635	41.257	.04045	.94711	1.507
3.40	48.434	44.637	45.311	.04442	1.0277	1.488
3.60	46.736	48.788	49.516	.04855	1.1104	1.471
3.80	45.174	53.086	53.869	.05281	1.1950	1.454
4.00	43.701	57.530	58.370	.05723	1.2814	1.438
4.20	42.397	62.118	63.015	.06178	1.3699	1.424
4.40	41.179	66.848	67.803	.06647	1.4601	1.410
4.60	40.039	71.710	72.726	.07130	1.5520	1.397
4.80	38.970	76.717	77.793	.07627	1.6455	1.384

MOLYBDENUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2 CM	PROTON PATH LENGTH GM/CM2 CM	PATH LENGTH STRAGGLING GM/CM2 CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	37.965	.08186	.08299	.00174	1.372	0.
5.50	35.696	.09528	.09658	.00199	1.345	0.
6.00	33.718	.10954	.11100	.00224	1.320	.00001
6.50	31.975	.12464	.12624	.00251	1.299	.00002
7.00	30.421	.14045	.14227	.00278	1.279	.00003
7.50	29.054	.15709	.15910	.00307	1.260	.00004
8.00	27.820	.17448	.17668	.00336	1.244	.00006
8.50	26.699	.19264	.19503	.00367	1.229	.00009
9.00	25.675	.21154	.21414	.00398	1.214	.00012
9.50	24.741	.23117	.23398	.00430	1.201	.00015
10.00	23.881	.25142	.25455	.00464	1.189	.00019
11.00	22.347	.29459	.29787	.00533	1.167	.00030
12.00	21.020	.34009	.34404	.00607	1.148	.00042
13.00	19.858	.38857	.39301	.00684	1.131	.00058
14.00	18.832	.43978	.44474	.00765	1.115	.00075
15.00	17.917	.49372	.49922	.00849	1.101	.00096
16.00	17.100	.55031	.55637	.00937	1.088	.00118
17.00	16.363	.60953	.61617	.01029	1.077	.00143
18.00	15.695	.67135	.67859	.01123	1.066	.00184
19.00	15.087	.73576	.74361	.01221	1.056	.00370
20.00	14.529	.80268	.81117	.01322	1.047	.00576
22.00	13.544	.94401	.95385	.01533	1.031	.00993
24.00	12.699	1.0952	1.1065	.01757	1.017	.01418
26.00	11.966	1.2561	1.2688	.01992	1.005	.01707
28.00	11.329	1.4264	1.4407	.02238	.9939	.01852
30.00	10.766	1.6059	1.6219	.02495	.9841	.02004
32.00	10.263	1.7946	1.8122	.02763	.9753	.02162
34.00	9.8116	1.9921	2.0116	.03041	.9673	.02325
36.00	9.4037	2.1986	2.2199	.03330	.9600	.02494
38.00	9.0333	2.4137	2.4370	.03628	.9533	.02668
40.00	8.6954	2.6374	2.6626	.03936	.9471	.02846
45.00	7.9666	3.1702	3.2001	.04748	.9337	.03311
50.00	7.3677	3.8813	3.9175	.05619	.9225	.03800
55.00	6.8661	4.5788	4.6210	.06544	.9129	.04314
60.00	6.4395	5.3248	5.3734	.07523	.9047	.04853
65.00	6.0720	6.1181	6.1735	.08553	.8975	.05416
70.00	5.7520	6.9574	7.0200	.09633	.8912	.06000
75.00	5.4706	7.8417	7.9117	.10760	.8857	.06603
80.00	5.2211	8.7697	8.8476	.11933	.8807	.07223
90.00	4.8012	10.753	10.848	.14413	.8722	.08508



## MOLYBDENUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GH/CM2	PROTON RANGE		PROTON PATH LENGTH GH/CM2 CM		PATH LENGTH STRAGGLING GH/CM2 C		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GH/CM2	CM	GH/CM2	CM	GH/CM2	PERCENT		
100.00	4.4554	12.899	1.2646	13.012	1.2757	.17055	1.311	.8651	.09840
110.00	4.1674	15.204	1.4905	15.335	1.5035	.19856	1.295	.8592	.11219
120.00	3.9241	17.657	1.7311	17.809	1.7460	.22806	1.231	.8542	.12647
130.00	3.7156	20.256	1.9859	20.430	2.0029	.25898	1.268	.8498	.14115
140.00	3.5348	22.994	2.2543	23.191	2.2736	.29122	1.256	.8460	.15615
150.00	3.3765	25.866	2.5359	26.086	2.5574	.32473	1.245	.8427	.17141
160.00	3.2369	28.880	2.8302	29.112	2.8542	.35943	1.235	.8397	.18693
170.00	3.1127	31.749	3.1366	32.263	3.1630	.39527	1.225	.8371	.20270
180.00	3.0010	35.239	3.4548	35.536	3.4839	.43221	1.216	.8348	.21870
190.00	2.9009	38.602	3.7846	38.927	3.8163	.47018	1.208	.8327	.23485
200.00	2.8104	42.078	4.1253	42.430	4.1598	.50914	1.200	.8307	.25113
210.00	2.7281	45.660	4.4765	46.042	4.5139	.54902	1.192	.8289	.26744
220.00	2.6530	49.348	4.8380	49.759	4.8784	.58980	1.185	.8273	.28373
230.00	2.5841	53.137	5.2095	53.579	5.2528	.63144	1.179	.8259	.29995
240.00	2.5208	57.024	5.5906	57.498	5.6371	.67388	1.172	.8245	.31608
250.00	2.4624	61.006	5.9810	61.512	6.0306	.71710	1.166	.8232	.33209
260.00	2.4084	65.080	6.3804	65.619	6.4333	.76106	1.160	.8221	.34803
270.00	2.3582	69.243	6.7885	69.816	6.8447	.80574	1.154	.8209	.36430
280.00	2.3116	73.492	7.2051	74.099	7.2646	.85110	1.149	.8199	.37994
290.00	2.2681	77.824	7.6298	78.467	7.6928	.89711	1.143	.8190	.39585
300.00	2.2275	82.224	8.0612	82.903	8.1277	.94374	1.138	.8180	.41169
310.00	2.1894	86.716	8.5016	87.431	8.5716	.99098	1.133	.8172	.42744
320.00	2.1537	91.204	8.9494	92.035	9.0231	1.0388	1.129	.8163	.44307
330.00	2.1202	95.926	9.4045	96.715	9.4818	1.0872	1.124	.8155	.45855
340.00	2.0887	100.64	9.8666	101.47	9.9477	1.1360	1.120	.8148	.47388
350.00	2.0589	105.42	10.336	106.29	10.420	1.1854	1.115	.8140	.48903
360.00	2.0308	110.27	10.811	111.18	10.900	1.2353	1.111	.8133	.50397
370.00	2.0043	115.19	11.293	116.14	11.386	1.2857	1.107	.8127	.51866
380.00	1.9791	120.17	11.782	121.16	11.878	1.3365	1.103	.8120	.53309
390.00	1.9553	125.21	12.276	126.24	12.376	1.3878	1.099	.8114	.54727
400.00	1.9327	130.32	12.776	131.38	12.881	1.4394	1.096	.8108	.56117
410.00	1.9113	135.48	13.282	136.58	13.391	1.4915	1.092	.8102	.57480
420.00	1.8908	140.70	13.794	141.84	13.906	1.5440	1.088	.8096	.58817
430.00	1.8714	145.97	14.311	147.16	14.427	1.5968	1.085	.8090	.60128
440.00	1.8529	151.30	14.833	152.53	14.954	1.6500	1.082	.8085	.61411
450.00	1.8353	156.67	15.360	157.95	15.485	1.7035	1.079	.8079	.62667
460.00	1.8184	162.10	15.893	163.42	16.022	1.7574	1.075	.8074	.63895
470.00	1.8023	167.58	16.430	168.95	16.563	1.8116	1.072	.8069	.65094
480.00	1.7869	173.11	16.972	174.52	17.110	1.8661	1.069	.8064	.66266
490.00	1.7722	178.69	17.518	180.14	17.661	1.9209	1.066	.8058	.67409

MOLYBDENUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CH	PROTON RANGE GH/CH2	PROTON PATH LENGTH GH/CH2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.7581	184.31	185.80	1.9760	1.063	.68524
510.00	1.7446	189.97	191.51	2.0314	1.061	.69610
520.00	1.7317	195.68	197.27	2.0870	1.058	.70669
530.00	1.7193	201.43	203.06	2.1429	1.055	.71699
540.00	1.7073	207.22	208.90	2.1991	1.053	.72702
550.00	1.6959	213.05	214.77	2.2555	1.050	.73676
560.00	1.6849	218.92	220.69	2.3121	1.048	.74624
570.00	1.6743	224.82	226.64	2.3690	1.045	.75544
580.00	1.6642	230.76	232.63	2.4261	1.043	.76438
590.00	1.6544	236.74	238.66	2.4834	1.041	.77305
600.00	1.6449	242.76	244.72	2.5409	1.038	.78146
620.00	1.6271	254.39	256.94	2.6565	1.034	.79752
640.00	1.6105	267.14	269.29	2.7729	1.030	.81259
660.00	1.5951	279.52	281.77	2.8900	1.026	.82671
680.00	1.5807	292.02	294.36	3.0077	1.022	.83992
700.00	1.5673	304.63	307.07	3.1261	1.018	.85226
720.00	1.5548	317.34	319.88	3.2450	1.014	.86377
740.00	1.5430	330.15	332.79	3.3646	1.011	.87449
760.00	1.5320	343.06	345.80	3.4846	1.008	.88467
780.00	1.5217	356.05	358.90	3.6051	1.005	.89373
800.00	1.5120	369.19	372.13	3.7262	1.001	.90233
820.00	1.5029	382.36	385.40	3.8476	.9983	.91030
840.00	1.4943	395.61	398.75	3.9695	.9959	.91768
860.00	1.4862	408.93	412.18	4.0918	.9927	.92451
880.00	1.4787	422.32	425.67	4.2145	.9901	.93082
900.00	1.4715	435.78	439.24	4.3375	.9875	.93664
920.00	1.4648	449.31	452.87	4.4609	.9850	.94201
940.00	1.4584	462.91	466.57	4.5846	.9826	.94696
960.00	1.4524	476.58	480.35	4.7087	.9803	.95152
1000.00	1.4414	504.32	508.28	4.9577	.9754	.95952

THE ELECTRON DENSITY OF MOLYBDENUM IS 2.638E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.029 BEV, AND THE MINIMUM ENERGY LOSS IS 1.3540 MEV/GH/CM2

## NEON

ATOMIC NUMBER 10  
ELEMENT NE  
ATOMS/MOLECULE 1  
ATOMIC WEIGHT 20.183  
ADJUSTED IONIZATION POTENTIAL 140.0

DENSITY = .89999 MG/CM<sup>3</sup>

PROCTON ENERGY MEV	ENERGY LOSS KEV/CM <sup>2</sup>	PROTON RANGE MG/CM <sup>2</sup>	PROTON PATH LENGTH MG/CM <sup>2</sup>	PROTON PATH LENGTH METER	PATH LENGTH STRAGGLING MG/CM <sup>2</sup>	PATH LENGTH STRAGGLING METER	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	435.83	30906	.31240	.00347	.01140	.00013	1.069	0.
.15	438.74	42313	.42674	.00474	.01427	.00016	.8466	0.
.20	417.72	53939	.54351	.00604	.01665	.00018	.7579	0.
.30	364.68	79330	.79865	.00881	.02139	.00024	.6689	0.
.40	319.66	10851	1.0918	.01213	.02676	.00030	.6153	0.
.50	284.03	14158	1.4240	.01582	.03307	.00037	.5764	0.
.60	256.16	17853	1.7951	.01995	.04041	.00045	.5460	0.
.70	232.91	21929	2.2044	.02449	.04859	.00054	.5215	0.
.80	214.01	26390	2.6523	.02947	.05756	.00064	.5011	0.
.90	202.68	31169	3.1320	.03480	.06695	.00074	.4840	0.
1.00	191.34	36230	3.6401	.04045	.07652	.00085	.4693	0.
1.20	169.54	47316	4.7527	.05281	.09719	.00108	.4449	0.
1.40	152.62	59726	5.9981	.06665	.11999	.00133	.4255	0.
1.60	139.23	73419	7.3722	.08191	.14476	.00161	.4097	.00001
1.80	128.33	88349	8.8701	.09856	.17129	.00190	.3965	.00001
2.00	119.22	10448	10.488	.11654	.19948	.00222	.3854	.00002
2.20	111.47	12178	12.224	.13582	.22926	.00255	.3759	.00003
2.40	104.79	14024	14.075	.15640	.26059	.00290	.3676	.00004
2.60	99.418	15979	16.036	.17818	.29331	.00326	.3604	.00005
2.80	94.223	18040	18.104	.20116	.32717	.00364	.3539	.00006
3.00	89.612	20210	20.280	.22534	.36250	.00403	.3481	.00008
3.20	85.488	22491	22.569	.25077	.39926	.00444	.3429	.00010
3.40	81.774	24880	24.964	.27739	.43742	.00486	.3381	.00012
3.60	78.410	27370	27.462	.30513	.47694	.00530	.3339	.00014
3.80	75.346	29962	30.061	.33402	.51780	.00575	.3299	.00016
4.00	72.541	32661	32.768	.36409	.55997	.00622	.3263	.00019
4.20	69.963	35463	35.578	.39531	.60344	.00670	.3228	.00022
4.40	67.584	38360	38.484	.42760	.64817	.00720	.3197	.00024
4.60	65.380	41367	41.498	.46110	.69416	.00771	.3168	.00028
4.80	63.333	44463	44.603	.49559	.74139	.00824	.3141	.00031

PRCTON ENERGY HEV	ENERGY LOSS HEV/ GM/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	61.424	0.4766	0.4781	0.0079	0.3116	0.0034
5.50	57.173	0.5608	0.5625	0.0092	0.3058	0.0044
6.00	53.530	0.6510	0.6530	0.0105	0.3008	0.0055
6.50	50.369	0.7471	0.7493	0.0119	0.2965	0.0068
7.00	47.597	0.8490	0.8515	0.0134	0.2926	0.0082
7.50	45.145	0.9566	0.9594	0.0149	0.2891	0.0099
8.00	42.958	1.0699	1.0730	0.0166	0.2860	0.0125
8.50	40.994	1.1888	1.1922	0.0183	0.2831	0.0156
9.00	39.219	1.3132	1.3169	0.0200	0.2806	0.0196
9.50	37.608	1.4431	1.4471	0.0218	0.2782	0.0245
10.00	36.136	1.5784	1.5828	0.0237	0.2760	0.0307
11.00	33.546	1.8651	1.8702	0.0277	0.2721	0.0389
12.00	31.315	2.1731	2.1789	0.0319	0.2686	0.0492
13.00	29.411	2.5020	2.5087	0.0364	0.2657	0.0619
14.00	27.747	2.8513	2.8589	0.0411	0.2630	0.0770
15.00	26.279	3.2209	3.2293	0.0460	0.2606	0.0946
16.00	24.974	3.6106	3.6199	0.0512	0.2585	0.1148
17.00	23.805	4.0197	4.0300	0.0566	0.2565	0.1376
18.00	22.752	4.4485	4.4599	0.0622	0.2547	0.1631
19.00	21.798	4.8967	4.9091	0.0680	0.2531	0.1914
20.00	20.929	5.3638	5.3773	0.0741	0.2516	0.2228
22.00	19.405	6.3547	6.3705	0.0868	0.2489	0.2670
24.00	18.109	7.4200	7.4383	0.1004	0.2465	0.3249
26.00	16.993	8.5580	8.5790	0.1149	0.2444	0.3969
28.00	16.022	9.7679	9.7917	0.1301	0.2426	0.4833
30.00	15.168	1.1049	1.1075	0.1461	0.2409	0.5854
32.00	14.412	1.2399	1.2428	0.1628	0.2394	0.7033
34.00	13.736	1.3818	1.3851	0.1803	0.2381	0.8389
36.00	13.128	1.5304	1.5340	0.1996	0.2369	0.9920
38.00	12.579	1.6857	1.6897	0.2175	0.2357	0.1161
40.00	12.080	1.8476	1.8520	0.2372	0.2347	0.1429
45.00	11.011	2.2808	2.2861	0.2894	0.2324	0.1928
50.00	10.139	2.7534	2.7598	0.3458	0.2304	0.2539
55.00	9.4140	3.2645	3.2720	0.4062	0.2287	0.3294
60.00	8.8004	3.8130	3.8217	0.4704	0.2273	0.4169
65.00	8.2743	4.3980	4.4080	0.5384	0.2260	0.5169
70.00	7.8180	5.0186	5.0300	0.6099	0.2249	0.6302
75.00	7.4183	5.6741	5.6868	0.6850	0.2239	0.7584
80.00	7.0651	6.3635	6.3777	0.7634	0.2229	0.8993
90.00	6.4689	7.8414	7.8588	0.9300	0.2213	0.1148

NEON

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON RANGE METER	PATH LENGTH GM/CM2	PATH LENGTH METER	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	5.9846	5.3861	104.97	9.4468	105.20	1.1088	1.2320	1.171	.17737
110.00	5.5832	5.0249	124.16	11.175	124.44	1.2993	1.4437	1.160	.19361
120.00	5.2450	4.7204	144.67	13.020	144.98	1.5007	1.6675	1.150	.21024
130.00	4.9559	4.4603	166.43	14.978	166.79	1.7125	1.9028	1.141	.22716
140.00	4.7061	4.2352	189.40	17.046	189.81	1.9342	2.1491	1.132	.24424
150.00	4.4878	4.0390	213.53	19.218	214.00	2.1652	2.4059	1.124	.26140
160.00	4.2956	3.8660	238.80	21.491	239.31	2.4052	2.6725	1.117	.27865
170.00	4.1251	3.7125	265.15	23.863	265.72	2.6536	2.9485	1.110	.29603
180.00	3.9726	3.5752	292.54	26.329	293.17	2.9101	3.2335	1.103	.31346
190.00	3.8356	3.4520	320.96	28.886	321.64	3.1743	3.5271	1.097	.33088
200.00	3.7118	3.3406	350.35	31.531	351.10	3.4459	3.8288	1.091	.34824
210.00	3.5994	3.2394	380.69	34.262	381.50	3.7245	4.1383	1.085	.36555
220.00	3.4969	3.1472	411.95	37.075	412.83	4.0098	4.4593	1.079	.38281
230.00	3.4031	3.0627	444.10	39.969	445.04	4.3015	4.7795	1.074	.39998
240.00	3.3168	2.9851	477.11	42.939	478.12	4.5993	5.1104	1.069	.41702
250.00	3.2373	2.9136	510.95	45.985	512.03	4.9031	5.4479	1.064	.43389
260.00	3.1636	2.8474	545.60	49.104	546.75	5.2124	5.7917	1.059	.45061
270.00	3.0937	2.7861	581.04	52.293	582.26	5.5272	6.1414	1.055	.46717
280.00	3.0324	2.7291	617.23	55.550	618.53	5.8472	6.4929	1.050	.48354
290.00	2.9733	2.6760	654.16	58.874	655.54	6.1721	6.8580	1.046	.49970
300.00	2.9182	2.6264	691.81	62.262	693.26	6.5018	7.2243	1.042	.51564
310.00	2.8666	2.5800	730.15	65.713	731.68	6.8361	7.5958	1.038	.53134
320.00	2.8183	2.5364	769.17	69.224	770.78	7.1748	7.9721	1.034	.54681
330.00	2.7729	2.4955	808.84	72.794	810.53	7.5178	8.3532	1.031	.56204
340.00	2.7301	2.4571	849.14	76.422	850.91	7.8648	8.7388	1.027	.57700
350.00	2.6898	2.4208	890.06	80.105	891.92	8.2157	9.1287	1.023	.59169
360.00	2.6518	2.3856	931.58	83.842	933.52	8.5704	9.5228	1.020	.60612
370.00	2.6159	2.3543	973.69	87.631	975.71	8.9288	9.9210	1.017	.62030
380.00	2.5819	2.3237	1016.4	91.471	1018.5	9.2907	10.323	1.014	.63423
390.00	2.5497	2.2947	1059.6	95.361	1061.8	9.6559	10.729	1.010	.64789
400.00	2.5191	2.2671	1103.3	99.299	1105.6	1.0024	11.138	1.007	.66127
410.00	2.4900	2.2410	1147.6	103.28	1150.0	1.0326	11.551	1.004	.67432
420.00	2.4624	2.2162	1192.4	107.31	1194.9	1.0771	11.968	1.002	.68700
430.00	2.4361	2.1925	1237.7	111.39	1240.2	1.1148	12.387	.998	.69931
440.00	2.4111	2.1700	1283.4	115.51	1286.1	1.1529	12.810	.996	.71125
450.00	2.3872	2.1485	1329.7	119.67	1332.4	1.1912	13.235	.9934	.72283
460.00	2.3644	2.1280	1376.3	123.87	1379.2	1.2297	13.664	.9907	.73404
470.00	2.3426	2.1084	1423.4	128.11	1426.4	1.2686	14.095	.9882	.74489
480.00	2.3218	2.0896	1471.0	132.39	1474.0	1.3077	14.530	.9857	.75539
490.00	2.3019	2.0717	1519.0	136.71	1522.1	1.3470	14.967	.9833	.76553

NEON

PROTON ENERGY MEV	ENERGY LOSS NEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH METER	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.2828	141.06	141.35	1570.6	1.3865	15.406	.2049	.77533
510.00	2.2645	145.45	145.75	1616.1	1.4263	15.848	.2047	.78478
520.00	2.2470	149.87	150.18	1668.7	1.4663	16.292	.2045	.79391
530.00	2.2302	154.33	154.65	1714.8	1.5065	16.739	.2043	.80271
540.00	2.2141	158.82	159.15	1768.3	1.5469	17.187	.2041	.81119
550.00	2.1985	163.35	163.68	1818.7	1.5874	17.638	.2039	.81935
560.00	2.1836	167.90	168.24	1869.4	1.6282	18.092	.2037	.82721
570.00	2.1693	172.49	172.84	1920.5	1.6692	18.547	.2036	.83478
580.00	2.1555	177.10	177.46	1971.8	1.7103	19.004	.2034	.84205
590.00	2.1422	181.75	182.12	2023.6	1.7517	19.463	.2032	.84904
600.00	2.1294	186.42	186.80	2075.6	1.7931	19.924	.2030	.85576
620.00	2.1052	195.85	196.25	2180.5	1.3766	20.851	.2026	.86841
640.00	2.0827	205.38	205.80	2286.7	1.9607	21.785	.2022	.88005
660.00	2.0617	215.02	215.45	2393.9	2.0453	22.726	.2018	.89076
680.00	2.0421	224.74	225.20	2502.2	2.1305	23.673	.2015	.90060
700.00	2.0238	234.56	235.04	2611.5	2.2163	24.625	.2011	.90961
720.00	2.0067	244.47	244.96	2721.8	2.3025	25.584	.2007	.91787
740.00	1.9906	254.46	254.97	2833.0	2.3892	26.547	.2003	.92542
760.00	1.9756	264.53	265.06	2945.1	2.4763	27.515	.2000	.93232
780.00	1.9614	274.67	275.22	3058.0	2.5639	28.488	.1996	.93962
800.00	1.9481	284.88	285.45	3171.7	2.6519	29.465	.1992	.94437
820.00	1.9356	295.16	295.75	3286.1	2.7402	30.447	.1989	.94960
840.00	1.9238	305.51	306.11	3401.3	2.8289	31.433	.1985	.95436
860.00	1.9127	315.92	316.54	3517.2	2.9180	32.423	.1981	.95870
880.00	1.9022	326.38	326.91	3633.7	3.0074	33.416	.1977	.96263
900.00	1.8923	336.91	337.58	3750.9	3.0972	34.413	.1974	.96621
920.00	1.8830	347.49	348.18	3868.7	3.1872	35.414	.1970	.96945
940.00	1.8741	358.13	358.84	3987.2	3.2775	36.417	.1966	.97240
960.00	1.8658	368.83	369.56	4106.2	3.3682	37.424	.1961	.97507
1000.00	1.8504	390.47	391.23	4347.0	3.5502	39.447	.1950	.97970

THE ELECTRON DENSITY OF NEON IS 2.985E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.203 BEV, AND THE MINIMUM ENERGY LOSS IS 1.7215 MEV/GM/CM2

# NICKEL

ELEMENT N1  
 ATOMIC NUMBER 28  
 ATOMS/MOLECULE 1  
 ATOMIC WEIGHT 58.710  
 ADJUSTED IONIZATION POTENTIAL 312.0

DENSITY = 8.9000 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT		PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/CH2	MEV/CH	MG/CM2	MM	MG/CM2	MM	MG/CM2	MM	PERCENT	PERCENT	
.10	253.07	2252.3	.49803	.00096	.51013	.00057	.02329	.00003	4.370	2.371	0.
.15	252.42	2246.5	.69459	.00078	.70795	.00060	.02927	.00003	4.135	1.887	0.
.20	251.26	2236.2	.89073	.00100	.90649	.00082	.03483	.00004	3.843	1.739	0.
.30	234.47	2086.8	1.2950	.00146	1.3164	.00148	.04432	.00005	3.367	1.621	0.
.40	206.16	1834.8	1.7431	.00196	1.7705	.00199	.05423	.00006	3.063	1.549	0.
.50	181.60	1616.2	2.2542	.00253	2.2883	.00257	.06627	.00007	2.896	1.489	0.
.60	164.93	1467.9	2.8260	.00328	2.8672	.00322	.08070	.00009	2.814	1.439	0.
.70	151.54	1348.7	3.4509	.00388	3.4998	.00393	.09660	.00011	2.760	1.397	0.
.80	141.13	1256.1	4.1291	.00464	4.1860	.00470	.11375	.00013	2.717	1.360	0.
.90	134.97	1201.2	4.8446	.00544	4.9098	.00552	.13111	.00015	2.670	1.327	0.
1.00	128.80	1146.3	5.5953	.00629	5.6686	.00637	.14846	.00017	2.619	1.298	0.
1.20	115.71	1029.8	7.2183	.00811	7.3094	.00821	.18502	.00021	2.531	1.247	0.
1.40	105.45	938.47	9.0128	.01013	9.1225	.01025	.22451	.00025	2.461	1.203	0.
1.60	97.375	866.64	10.969	.01233	11.099	.01247	.26645	.00030	2.401	1.165	0.
1.80	90.648	806.77	13.078	.01469	13.228	.01486	.31053	.00035	2.347	1.133	0.
2.00	84.935	755.92	15.339	.01723	15.510	.01743	.35663	.00040	2.299	1.104	0.
2.20	80.036	712.32	17.743	.01994	17.937	.02015	.40469	.00045	2.256	1.079	0.
2.40	75.821	674.81	20.288	.02280	20.505	.02304	.45459	.00051	2.217	1.057	0.
2.60	72.078	641.49	22.971	.02581	23.211	.02608	.50618	.00057	2.181	1.037	0.
2.80	68.749	611.87	25.789	.02898	26.054	.02927	.55949	.00063	2.147	1.018	0.
3.00	65.764	585.30	28.738	.03229	29.029	.03262	.61450	.00069	2.117	1.002	0.
3.20	63.069	561.31	31.818	.03575	32.136	.03611	.67116	.00075	2.089	.9865	0.
3.40	60.619	539.51	35.029	.03936	35.373	.03974	.72946	.00082	2.062	.9726	0.
3.60	58.380	519.59	38.364	.04311	38.736	.04352	.78937	.00089	2.038	.9597	0.
3.80	56.324	501.29	41.821	.04699	42.222	.04744	.85088	.00096	2.015	.9478	.00001
4.00	54.427	484.40	45.406	.05102	45.835	.05150	.91410	.00103	1.994	.9366	.00001
4.20	52.670	468.77	49.114	.05518	49.573	.05570	.97932	.00110	1.975	.9263	.00001
4.40	51.038	454.24	52.940	.05948	53.429	.06003	1.0465	.00118	1.959	.9166	.00001
4.60	49.516	440.69	56.888	.06392	57.409	.06450	1.1155	.00125	1.943	.9075	.00002
4.80	48.094	428.03	60.955	.06849	61.507	.06911	1.1863	.00133	1.929	.8988	.00002

NICKEL

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
5.00	46.761	416.17	.06514	.00732	.06572	.00738	.00126	.00014	1.915	.00002
5.50	43.765	389.51	.07611	.00855	.07678	.00863	.00145	.00016	1.886	.00004
6.00	41.181	366.51	.08781	.00995	.08857	.00995	.00165	.00019	1.860	.00006
6.50	38.924	346.42	.10021	.01126	.10106	.01136	.00186	.00021	1.837	.00009
7.00	36.934	328.71	.11331	.01273	.11426	.01284	.00207	.00023	1.816	.00012
7.50	35.162	312.94	.12709	.01428	.12813	.01440	.00230	.00026	1.797	.00016
8.00	33.569	298.77	.14154	.01590	.14269	.01603	.00254	.00029	1.779	.00021
8.50	32.127	285.93	.15666	.01760	.15792	.01774	.00278	.00031	1.763	.00027
9.00	30.815	274.26	.17245	.01938	.17382	.01953	.00304	.00034	1.748	.00033
9.50	29.628	263.69	.18888	.02122	.19037	.02139	.00330	.00037	1.734	.00040
10.00	28.527	253.89	.20595	.02314	.20756	.02332	.00357	.00040	1.721	.00048
11.00	26.620	236.92	.24203	.02719	.24388	.02740	.00414	.00046	1.696	.00065
12.00	24.979	222.31	.28057	.03152	.28268	.03176	.00473	.00053	1.674	.00088
13.00	23.550	209.60	.32154	.03613	.32393	.03640	.00536	.00060	1.654	.00149
14.00	22.294	198.41	.36492	.04100	.36760	.04130	.00601	.00068	1.636	.00213
15.00	21.179	188.50	.41066	.04614	.41364	.04648	.00670	.00075	1.619	.00348
16.00	20.183	179.63	.45872	.05154	.46202	.05191	.00741	.00083	1.604	.00586
17.00	19.287	171.66	.50908	.05720	.51270	.05761	.00815	.00092	1.590	.00826
18.00	18.476	164.44	.56174	.06312	.56570	.06356	.00892	.00100	1.576	.01067
19.00	17.739	157.88	.61665	.06929	.62096	.06977	.00971	.00109	1.564	.01311
20.00	17.066	151.88	.67377	.07570	.67845	.07623	.01053	.00118	1.553	.01556
22.00	15.879	141.32	.79460	.08928	.80004	.08989	.01225	.00138	1.532	.02052
24.00	14.865	132.30	.92406	.10383	.93031	.10453	.01408	.00158	1.513	.02555
26.00	13.988	124.49	1.0620	.11932	1.0691	.12012	.01600	.00180	1.497	.02889
28.00	13.221	117.67	1.2082	.13575	1.2162	.13665	.01802	.00202	1.482	.03048
30.00	12.545	111.65	1.3626	.15310	1.3716	.15411	.02013	.00226	1.468	.03213
32.00	11.944	106.30	1.5251	.17136	1.5350	.17247	.02234	.00251	1.455	.03384
34.00	11.406	101.51	1.6954	.19050	1.7064	.19173	.02464	.00277	1.444	.03562
36.00	10.920	97.191	1.8736	.21052	1.8857	.21187	.02702	.00304	1.433	.03746
38.00	10.481	93.277	2.0595	.23141	2.0727	.23288	.02949	.00331	1.423	.03935
40.00	10.080	89.713	2.2530	.25315	2.2673	.25475	.03205	.00360	1.414	.04130
45.00	9.2182	82.042	2.7693	.31115	2.7866	.31311	.03881	.00436	1.393	.04637
50.00	8.5126	75.762	3.3310	.37427	3.3516	.37659	.04606	.00518	1.374	.05171
55.00	7.9231	70.516	3.9367	.44233	3.9610	.44505	.05380	.00605	1.358	.05732
60.00	7.4228	65.063	4.5854	.51521	4.6134	.51836	.06200	.00697	1.344	.06321
65.00	6.9924	62.232	5.2979	.59279	5.3078	.59638	.07064	.00794	1.331	.06934
70.00	6.6181	58.901	6.0070	.67494	6.0431	.67900	.07971	.00896	1.319	.07570
75.00	6.2891	55.973	6.7779	.76156	6.8435	.76612	.08920	.01002	1.308	.08225
80.00	5.9980	53.382	7.5876	.85254	7.6329	.85762	.09909	.01113	1.298	.08898
90.00	5.5053	48.997	9.3502	1.0472	9.3753	1.0534	.12002	.01349	1.280	.10289



NICKEL

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PATH LENGTH STRAGGLING GM/CH2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	5.1036	11.138	11.263	1.4241	.5835	.11725
110.00	4.7700	13.215	13.292	1.6617	.5799	.13208
120.00	4.4881	15.365	15.455	1.9124	.5759	.14738
130.00	4.2467	17.645	17.746	2.1753	.5743	.16306
140.00	4.0376	20.047	20.162	2.4498	.5720	.17903
150.00	3.8548	22.569	22.698	2.7353	.5700	.19521
160.00	3.6935	25.205	25.349	3.0314	.5682	.21161
170.00	3.5501	27.952	28.112	3.3373	.5666	.22827
180.00	3.4219	30.806	30.982	3.6528	.5651	.24513
190.00	3.3065	33.744	33.955	3.9773	.5638	.26212
200.00	3.2021	36.821	37.029	4.3104	.5626	.27921
210.00	3.1073	39.974	40.200	4.6518	.5615	.29636
220.00	3.0208	43.221	43.464	5.0009	.5605	.31356
230.00	2.9415	46.557	46.819	5.3576	.5595	.33077
240.00	2.8686	49.981	50.262	5.7214	.5586	.34796
250.00	2.8014	53.490	53.790	6.0921	.5578	.36508
260.00	2.7392	57.081	57.401	6.4693	.5570	.38210
270.00	2.6815	60.751	61.091	6.8528	.5563	.39897
280.00	2.6279	64.498	64.858	7.2423	.5556	.41566
290.00	2.5779	68.319	68.701	7.6376	.5549	.43217
300.00	2.5312	72.213	72.616	8.0384	.5543	.44846
310.00	2.4875	76.177	76.601	8.4444	.5537	.46454
320.00	2.4465	80.209	80.655	8.8536	.5532	.48041
330.00	2.4079	84.307	84.776	9.2717	.5526	.49606
340.00	2.3717	88.469	88.960	9.6924	.5521	.51148
350.00	2.3375	92.694	93.208	1.0118	.5516	.52664
360.00	2.3053	96.978	97.516	1.0547	.5511	.54155
370.00	2.2748	101.32	101.88	1.0981	.5506	.55622
380.00	2.2459	105.72	106.31	1.1419	.5501	.57063
390.00	2.2186	110.18	110.79	1.1860	.5497	.58476
400.00	2.1926	114.69	115.32	1.2306	.5492	.59863
410.00	2.1680	119.25	119.91	1.2755	.5488	.61219
420.00	2.1445	123.86	124.55	1.3207	.5484	.62545
430.00	2.1222	128.53	129.23	1.3663	.5480	.63840
440.00	2.1010	133.24	133.97	1.4122	.5476	.65103
450.00	2.0807	137.99	138.75	1.4584	.5472	.66334
460.00	2.0614	142.80	143.58	1.5049	.5468	.67534
470.00	2.0429	147.64	148.45	1.5516	.5464	.68701
480.00	2.0252	152.53	153.37	1.5987	.5460	.69838
490.00	2.0083	157.47	158.33	1.6460	.5456	.70942

NICKEL

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	MEV/CM	PROTON RANGE GM/CM2	CM	PROTON PATH LENGTH GM/CM2	CM	PATH LENGTH STRAGGLING GM/CM2	CM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.9921	17.730	162.44	18.252	163.33	18.352	1.6936	.19029	1.037	.5452	.72015
510.00	1.9766	17.592	167.45	18.815	168.37	18.918	1.7415	.19567	1.034	.5448	.73057
520.00	1.9618	17.460	172.50	19.382	173.45	19.488	1.7895	.20107	1.032	.5445	.74069
530.00	1.9475	17.333	177.59	19.954	178.56	20.063	1.8378	.20650	1.029	.5441	.75050
540.00	1.9338	17.211	182.72	20.530	183.72	20.642	1.8864	.21195	1.027	.5437	.76000
550.00	1.9207	17.094	187.88	21.110	188.90	21.225	1.9351	.21743	1.024	.5433	.76922
560.00	1.9080	16.982	193.07	21.694	194.13	21.812	1.9841	.22293	1.022	.5430	.77814
570.00	1.8959	16.874	198.30	22.281	199.39	22.403	2.0333	.22846	1.020	.5426	.78677
580.00	1.8842	16.770	203.57	22.873	204.68	22.997	2.0827	.23401	1.018	.5422	.79513
590.00	1.8730	16.669	208.86	23.468	210.00	23.596	2.1322	.23958	1.015	.5419	.80320
600.00	1.8621	16.573	214.19	24.066	215.35	24.197	2.1820	.24517	1.013	.5415	.81101
620.00	1.8417	16.391	224.93	25.273	226.16	25.411	2.2820	.25641	1.009	.5408	.82584
640.00	1.8226	16.221	235.79	26.493	237.07	26.637	2.3827	.26772	1.005	.5401	.83966
660.00	1.8049	16.063	246.76	27.726	248.10	27.876	2.4841	.27911	1.001	.5393	.85251
680.00	1.7883	15.915	257.84	28.970	259.23	29.127	2.5861	.29057	.9976	.5386	.86446
700.00	1.7729	15.779	269.01	30.226	270.47	30.389	2.6886	.30209	.9941	.5379	.87553
720.00	1.7584	15.659	280.28	31.492	281.79	31.662	2.7917	.31367	.9907	.5372	.88580
740.00	1.7449	15.530	291.64	32.768	293.21	32.945	2.8952	.32531	.9874	.5364	.89530
760.00	1.7322	15.417	303.08	34.054	304.72	34.238	2.9993	.33700	.9843	.5357	.90408
	1.7203	15.311	314.61	35.350	316.30	35.540	3.1038	.34874	.9813	.5350	.91216
800.00	1.7091	15.211	326.22	36.653	327.97	36.850	3.2088	.36054	.9784	.5342	.91965
820.00	1.6986	15.118	337.89	37.966	339.71	38.169	3.3141	.37237	.9756	.5335	.92654
840.00	1.6888	15.030	349.64	39.286	351.52	39.496	3.4199	.38425	.9729	.5328	.93287
860.00	1.6794	14.947	361.46	40.614	363.40	40.831	3.5260	.39618	.9703	.5320	.93870
880.00	1.6707	14.869	373.35	41.949	375.34	42.173	3.6325	.40814	.9678	.5313	.94405
900.00	1.6624	14.795	385.29	43.291	387.35	43.522	3.7393	.42014	.9654	.5305	.94896
920.00	1.6546	14.726	397.30	44.640	399.42	44.876	3.8464	.43218	.9630	.5297	.95347
940.00	1.6472	14.660	409.37	45.997	411.55	46.241	3.9538	.44425	.9607	.5289	.95760
960.00	1.6403	14.599	421.51	47.360	423.74	47.612	4.0616	.45636	.9585	.5279	.96138
1000.00	1.6275	14.485	446.06	50.119	448.42	50.384	4.2779	.48066	.9540	.5257	.96800

THE ELECTRON DENSITY OF NICKEL IS 2.873E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.078 BEV, AND THE MINIMUM ENERGY LOSS IS 1.5276 MEV/GM/CM2

# NITROGEN (DIATOMIC)

ELEMENT N  
 ATOMIC NUMBER 7  
 ATOMS/MOLECULE 2  
 ATOMIC WEIGHT 14.007  
 ADJUSTED IONIZATION POTENTIAL 86.70

DENSITY = 1.2504 MG/CM3

PROCTON ENERGY MEV	ENERGY LOSS GM/CM2 KEV/CM	PROTON RANGE MG/CM2 METER	PROTON PATH LENGTH MG/CM2 METER	PATH LENGTH STRAGGLING HG/CM2 METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	774.81	13462	.00108	.00461	.8112	0.
.15	693.26	20273	.00162	.00596	.5794	0.
.20	506.52	27960	.00224	.00742	.4811	0.
.30	478.65	46564	.00372	.01139	.3923	0.
.40	401.55	69372	.00555	.01641	.3516	0.
.50	344.76	96228	.00770	.02223	.3279	0.
.60	307.28	12696	.01015	.02873	.3121	0.
.70	277.95	16108	.01288	.03563	.3007	0.
.80	254.00	19862	.01588	.04301	.2918	0.
.90	238.30	23913	.01912	.05070	.2846	0.
1.00	222.58	28246	.02259	.05861	.2784	0.
1.20	196.24	37812	.03024	.07570	.2682	0.
1.40	176.18	48563	.03884	.09441	.2602	.00001
1.60	160.33	60454	.04835	.11461	.2535	.00001
1.80	147.44	73449	.05874	.13623	.2479	.00002
2.00	136.71	87516	.06999	.15922	.2430	.00003
2.20	127.61	10263	.08208	.18353	.2388	.00004
2.40	119.78	11879	.09500	.20913	.2350	.00006
2.60	112.96	13595	.10873	.23600	.2317	.00008
2.80	106.96	15412	.12326	.26410	.2287	.00010
3.00	101.62	17327	.13857	.29343	.2259	.00013
3.20	96.852	19340	.15467	.32396	.2234	.00016
3.40	92.553	21448	.17153	.35567	.2211	.00019
3.60	88.658	23653	.18916	.38855	.2190	.00022
3.80	85.110	25951	.20754	.42260	.2170	.00026
4.00	81.863	28343	.22667	.45779	.2152	.00029
4.20	78.875	30828	.24654	.49411	.2135	.00033
4.40	76.126	33404	.26715	.53155	.2119	.00038
4.60	73.577	36071	.28848	.57010	.2104	.00042
4.80	71.210	38830	.31054	.60976	.2090	.00047

# NITROGEN (DIATOMIC)

PRCTCN ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	KEV/CM	GM/CM2	METER	GM/CM2	METER	GM/CM2	METER PERCENT		
5.00	59.006	86.285	0.168	.33332	.04176	.33401	.00065	1.558	.2077	.00052
5.50	64.101	80.151	.04919	.39337	.04929	.39418	.00076	1.536	.2046	.00065
6.00	59.828	74.809	.05726	.45794	.05738	.45887	.00087	1.517	.2020	.00081
6.50	56.214	70.291	.06587	.52680	.06600	.52786	.00099	1.501	.1996	.00247
7.00	53.049	66.332	.07501	.59990	.07516	.60108	.00112	1.485	.1975	.00508
7.50	50.251	62.834	.08468	.67720	.08484	.67853	.00125	1.473	.1956	.00768
8.00	47.759	59.718	.09487	.75871	.09505	.76019	.00139	1.461	.1939	.01027
8.50	45.525	56.924	.10558	.84436	.10578	.84599	.00153	1.449	.1923	.01286
9.00	43.508	54.403	.11680	.93411	.11702	.93590	.00168	1.439	.1909	.01545
9.50	41.679	52.115	.12852	1.0278	.12876	1.0298	.00184	1.429	.1895	.01804
10.00	40.011	50.030	.14075	1.1256	.14101	1.1277	.00200	1.420	.1883	.02063
11.00	37.080	46.365	.16668	1.3330	.16699	1.3355	.00235	1.404	.1861	.02580
12.00	34.585	43.245	.19458	1.5561	.19494	1.5590	.00271	1.390	.1841	.03097
13.00	32.433	40.555	.22440	1.7946	.22481	1.7979	.00310	1.378	.1824	.03614
14.00	30.557	38.209	.25613	2.0484	.25660	2.0521	.00351	1.366	.1809	.04131
15.00	28.906	36.144	.28974	2.3171	.29026	2.3213	.00394	1.356	.1795	.04649
16.00	27.440	34.312	.32520	2.6008	.32578	2.6054	.00439	1.347	.1782	.05168
17.00	26.130	32.673	.36250	2.8990	.36314	2.9042	.00486	1.338	.1771	.05687
18.00	24.952	31.200	.40160	3.2118	.40231	3.2175	.00535	1.330	.1760	.06207
19.00	23.885	29.856	.44251	3.5389	.44328	3.5451	.00586	1.323	.1751	.06727
20.00	22.916	28.654	.48519	3.8803	.48604	3.8871	.00640	1.316	.1742	.07247
22.00	21.216	26.529	.57587	4.6051	.57682	4.6131	.00752	1.303	.1726	.08290
24.00	19.776	24.727	.67338	5.3853	.67453	5.3945	.00872	1.292	.1712	.09334
26.00	18.537	23.179	.77773	6.2198	.77905	6.2304	.00999	1.282	.1699	.09964
28.00	17.461	21.833	.88878	7.1079	.89028	7.1200	.01133	1.273	.1688	.10170
30.00	16.516	20.652	1.0064	8.0487	1.0081	8.0622	.01275	1.265	.1678	.10384
32.00	15.680	19.606	1.1305	9.0414	1.1324	9.0565	.01424	1.257	.1669	.10605
34.00	14.933	18.673	1.2611	10.085	1.2632	10.102	.01579	1.250	.1661	.10832
36.00	14.263	17.835	1.3980	11.180	1.4003	11.199	.01741	1.243	.1654	.11066
38.00	13.658	17.078	1.5411	12.324	1.5436	12.345	.01910	1.237	.1647	.11306
40.00	13.109	16.392	1.6903	13.518	1.6931	13.540	.02085	1.231	.1640	.11550
45.00	11.934	14.922	2.0900	16.714	2.0934	16.742	.02550	1.218	.1626	.12180
50.00	10.977	13.725	2.5265	20.207	2.5307	20.239	.03054	1.207	.1614	.12829
55.00	10.182	12.731	2.9993	23.986	3.0041	24.025	.03594	1.196	.1604	.13502
60.00	9.5101	11.891	3.5070	28.047	3.5126	28.091	.04169	1.187	.1595	.14202
65.00	8.9349	11.172	4.0489	32.381	4.0553	32.432	.04778	1.178	.1597	.14926
70.00	8.4364	10.549	4.6242	36.982	4.6315	37.040	.05421	1.170	.1580	.15669
75.00	8.0002	10.003	5.2321	41.844	5.2404	41.910	.06095	1.163	.1573	.16429
80.00	7.6150	9.5218	5.8720	46.961	5.8812	47.035	.06800	1.156	.1568	.17201
90.00	6.9655	8.7097	7.2448	57.940	7.2561	58.030	.08300	1.144	.1557	.18770

NITROGEN (DIATOMIC)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2 METER	PROTON PATH LENGTH GM/CM2 METER	PATH LENGTH STRAGGLING GM/CM2 METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	6.4386	8.7373	8.7509	.09912	.1549	.20354
110.00	6.0023	10.345	10.361	.11631	.1542	.21959
120.00	5.6349	12.063	12.082	.13451	.1535	.23599
130.00	5.3212	13.888	13.909	.15366	.1529	.25262
140.00	5.0502	15.815	15.839	.17372	.1524	.26937
150.00	4.8137	17.841	17.868	.19465	.1520	.28613
160.00	4.6055	19.962	19.993	.21640	.1515	.30298
170.00	4.4208	22.176	22.209	.23893	.1511	.31996
180.00	4.2558	24.479	24.516	.26221	.1508	.33703
190.00	4.1076	26.867	26.908	.28619	.1505	.35412
200.00	3.9737	29.340	29.384	.31086	.1501	.37117
210.00	3.8521	31.892	31.940	.33618	.1499	.38824
220.00	3.7413	34.523	34.575	.36212	.1496	.40540
230.00	3.6399	37.229	37.285	.38866	.1493	.42260
240.00	3.5467	40.009	40.069	.41576	.1491	.43979
250.00	3.4609	42.859	42.923	.44341	.1488	.45694
260.00	3.3815	45.779	45.847	.47159	.1486	.47395
270.00	3.3079	48.765	48.837	.50026	.1484	.49072
280.00	3.2395	51.815	51.892	.52942	.1482	.50723
290.00	3.1758	54.929	55.010	.55904	.1480	.52345
300.00	3.1163	58.103	58.189	.58911	.1478	.53938
310.00	3.0607	61.337	61.427	.61960	.1476	.55496
320.00	3.0085	64.628	64.723	.65050	.1474	.57017
330.00	2.9594	67.975	68.075	.68180	.1472	.58500
340.00	2.9133	71.376	71.481	.71348	.1470	.59943
350.00	2.8699	74.829	74.939	.74553	.1469	.61347
360.00	2.8288	78.334	78.444	.77793	.1467	.62724
370.00	2.7901	81.889	81.999	.81064	.1465	.64087
380.00	2.7534	85.492	85.617	.84373	.1464	.65432
390.00	2.7186	89.142	89.272	.87711	.1462	.66759
400.00	2.6856	92.838	92.973	.91080	.1460	.68125
410.00	2.6543	96.578	96.719	.94478	.1459	.69342
420.00	2.6245	100.36	100.51	.97905	.1457	.70581
430.00	2.5961	104.19	104.34	1.0136	.1456	.71784
440.00	2.5691	108.05	108.21	1.0484	.1454	.72949
450.00	2.5433	111.96	112.12	1.0835	.1453	.74078
460.00	2.5187	115.91	116.07	1.1188	.1451	.75170
470.00	2.4952	119.89	120.06	1.1543	.1450	.76226
480.00	2.4728	123.91	124.09	1.1901	.1448	.77246
490.00	2.4513	127.97	128.15	1.2261	.1447	.78230

# NITROGEN (DIATOMIC)

PROTON ENERGY MEV	ENERGY LOSS GM/CM2 KEV/CM	PROTON RANGE GM/CM2 METER	PROTON PATH LENGTH G1 M2 METER	PATH LENGTH STRAGGLING GM/CM2 METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.4307	132.06	132.25	1.2623	.1445	.79181
510.00	2.4109	136.18	136.38	1.2988	.1444	.80097
520.00	2.3920	140.34	140.54	1.3354	.1442	.80979
530.00	2.3739	144.53	144.74	1.3722	.1441	.81829
540.00	2.3564	148.75	148.97	1.4093	.1439	.82647
550.00	2.3397	153.01	153.23	1.4465	.1438	.83434
560.00	2.3236	157.29	157.52	1.4839	.1437	.84190
570.00	2.3081	161.60	161.83	1.5214	.1435	.84917
580.00	2.2932	165.94	166.18	1.5592	.1434	.85614
590.00	2.2788	170.31	170.56	1.5971	.1432	.86284
600.00	2.2650	174.71	174.96	1.6351	.1431	.86926
620.00	2.2389	183.58	183.84	1.7117	.1428	.88132
640.00	2.2145	192.55	192.82	1.7889	.1425	.89238
660.00	2.1918	201.61	201.90	1.8666	.1422	.90251
680.00	2.1706	210.77	211.07	1.9449	.1420	.91178
700.00	2.1508	220.02	220.33	2.0237	.1417	.92024
720.00	2.1323	229.34	229.67	2.1029	.1414	.92796
740.00	2.1149	238.75	239.09	2.1826	.1411	.93498
760.00	2.0986	248.23	248.58	2.2627	.1409	.94137
780.00	2.0832	257.78	258.15	2.3432	.1406	.94718
800.00	2.0688	267.40	267.78	2.4242	.1403	.95244
820.00	2.0552	277.09	277.48	2.5054	.1400	.95721
840.00	2.0424	286.84	287.24	2.5871	.1398	.96153
860.00	2.0303	296.65	297.07	2.6691	.1395	.96543
880.00	2.0189	306.52	306.95	2.7514	.1392	.96896
900.00	2.0082	316.45	316.89	2.8340	.1389	.97214
920.00	1.9980	326.42	326.88	2.9170	.1387	.97501
940.00	1.9884	336.45	336.92	3.0002	.1384	.97760
960.00	1.9793	346.54	347.02	3.0837	.1380	.97993
1000.00	1.9625	366.94	367.45	3.2515	.1372	.98393

THE ELECTRON DENSITY OF NITROGEN (DIATOMIC) IS 3.011E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.276 BEV, AND THE MINIMUM ENERGY LOSS IS 1.8170 MEV/GM/CM2

## OSMIUM

ELEMENT  
OS

ATOMIC  
NUMBER  
76

ATOMS/  
MOLECULE  
1

ATOMIC  
WEIGHT  
190.20

ADJUSTED  
IONIZATION  
POTENTIAL  
751.4

DENSITY = 22.500 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM <sup>2</sup>	PROTON RANGE MG/CM <sup>2</sup>	PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
			MG/CM <sup>2</sup>	MM	MG/CM <sup>2</sup>	MM		
.10	113.68	2557.9	1.2063	.00054	.06445	.00003	5.134	0.
.15	120.35	2707.9	1.6283	.00072	.08025	.00004	4.164	0.
.20	120.65	2714.6	2.0320	.00090	.09344	.00004	3.874	0.
.30	111.51	2509.0	2.8617	.00127	.12048	.00005	3.719	0.
.40	96.978	2227.0	3.7794	.00168	.15060	.00007	3.677	0.
.50	88.515	1991.6	4.8113	.00214	.18498	.00008	3.652	0.
.60	81.139	1825.6	5.9516	.00265	.22250	.00010	3.629	0.
.70	75.552	1699.9	7.1844	.00319	.26164	.00012	3.605	0.
.80	69.585	1565.7	8.5134	.00378	.30292	.00013	3.578	0.
.90	67.586	1525.7	9.9212	.00441	.34498	.00015	3.550	0.
1.00	65.585	1475.7	11.374	.00506	.38516	.00017	3.521	0.
1.20	61.002	1372.5	14.435	.00642	.46477	.00021	3.458	0.
1.40	57.012	1282.8	17.723	.00788	.54944	.00024	3.392	0.
1.60	53.552	1204.9	21.258	.00944	.63929	.00028	3.327	0.
1.80	50.533	1137.0	24.974	.01110	.73351	.00033	3.264	0.
2.00	47.688	1077.5	28.926	.01286	.83159	.00037	3.203	0.
2.20	45.527	1024.3	33.091	.01471	.93322	.00041	3.146	0.
2.40	43.441	977.43	37.470	.01665	1.0383	.00046	3.093	0.
2.60	41.566	935.24	42.034	.01869	1.1465	.00051	3.043	0.
2.80	39.072	897.12	46.841	.02082	1.2579	.00056	2.997	0.
3.00	36.334	862.51	51.827	.02303	1.3721	.00061	2.953	0.
3.20	36.033	830.99	57.011	.02534	1.4893	.00066	2.912	0.
3.40	35.650	802.12	62.388	.02773	1.6093	.00072	2.874	0.
3.60	34.469	775.54	67.957	.03020	1.7319	.00077	2.838	0.
3.80	33.374	750.91	73.713	.03276	1.8573	.00083	2.804	0.
4.00	32.356	728.00	79.655	.03540	1.9853	.00088	2.772	0.
4.20	31.411	706.74	85.763	.03813	2.1159	.00094	2.742	0.
4.40	30.505	686.36	92.097	.04093	2.2493	.00100	2.713	0.
4.60	29.698	668.21	98.597	.04382	2.3852	.00106	2.686	0.
4.80	28.939	651.14	105.26	.04678	2.5234	.00112	2.660	0.

## OSMIUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PRGTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	HEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
5.00	28.393	638.85	.11207	.00498	.11510	.00512	.00266	.00012	2.637	0.
5.50	26.742	601.69	.12984	.00577	.13328	.00592	.00302	.00013	2.581	0.
6.00	25.303	569.31	.14866	.00661	.15252	.00678	.00339	.00015	2.530	0.
6.50	24.037	540.83	.16851	.00749	.17281	.00760	.00378	.00017	2.485	.00001
7.00	22.912	515.52	.18938	.00842	.19412	.00863	.00419	.00019	2.444	.00003
7.50	21.906	492.88	.21123	.00939	.21644	.00962	.00452	.00021	2.407	.00005
8.00	20.993	472.35	.23406	.01040	.23975	.01066	.00507	.00023	2.373	.00006
8.50	20.182	454.09	.25785	.01146	.26404	.01173	.00552	.00025	2.343	.00006
9.00	19.441	437.43	.28255	.01256	.28925	.01286	.00600	.00027	2.314	.00007
9.50	18.762	422.14	.30828	.01370	.31550	.01402	.00648	.00029	2.288	.00007
10.00	18.137	408.09	.33484	.01488	.34259	.01523	.00698	.00031	2.264	.00008
11.00	17.524	383.03	.39069	.01736	.39956	.01776	.00801	.00036	2.219	.00009
12.00	16.062	361.39	.45004	.02000	.46007	.02045	.00909	.00040	2.180	.00012
13.00	15.218	342.40	.51282	.02279	.52406	.02329	.01022	.00045	2.145	.00017
14.00	14.473	325.64	.57897	.02573	.59147	.02629	.01139	.00051	2.114	.00023
15.00	13.808	310.68	.64842	.02882	.66223	.02943	.01260	.00058	2.086	.00031
16.00	13.211	297.24	.72110	.03205	.73628	.03272	.01386	.00062	2.061	.00042
17.00	12.671	285.09	.79698	.03542	.81356	.03616	.01515	.00067	2.037	.00055
18.00	12.180	274.05	.87611	.03894	.89414	.03974	.01649	.00073	2.016	.00070
19.00	11.732	263.97	.95827	.04259	.97779	.04346	.01786	.00079	1.997	.00087
20.00	11.321	254.72	1.0435	.04639	1.0646	.04731	.01928	.00086	1.979	.00107
22.00	10.592	238.32	1.2231	.05436	1.2473	.05544	.02222	.00099	1.946	.00153
24.00	9.9641	224.19	1.4145	.06287	1.4421	.06409	.02530	.00112	1.917	.00207
26.00	9.4138	211.81	1.6175	.07189	1.6487	.07328	.02853	.00127	1.892	.00304
28.00	8.9598	201.60	1.8320	.08142	1.8669	.08297	.03189	.00142	1.869	.00444
30.00	8.5340	192.01	2.0565	.09140	2.0953	.09312	.03537	.00157	1.849	.00588
32.00	8.1530	183.44	2.2929	.10190	2.3356	.10381	.03897	.00173	1.831	.00738
34.00	7.8101	175.73	2.5392	.11285	2.5861	.11494	.04270	.00190	1.814	.00894
36.00	7.4982	168.71	2.7963	.12428	2.8475	.12656	.04656	.00207	1.799	.01054
38.00	7.2165	162.37	3.0640	.13618	3.1197	.13865	.05055	.00225	1.785	.01219
40.00	6.9586	156.57	3.3414	.14851	3.4017	.15119	.05468	.00243	1.772	.01389
45.00	6.3997	143.99	4.0796	.18132	4.1520	.18453	.06552	.00291	1.743	.01832
50.00	5.9378	133.60	4.8786	.21682	4.9639	.22062	.07711	.00343	1.719	.02299
55.00	5.5486	124.84	5.7366	.25496	5.8357	.25937	.08940	.00397	1.699	.02789
60.00	5.2162	117.36	6.6519	.29564	6.7656	.30069	.10236	.00455	1.681	.03305
65.00	4.9287	110.90	7.6229	.33880	7.7521	.34454	.11596	.00515	1.665	.03843
70.00	4.6777	105.25	8.6458	.38426	8.7911	.39071	.13018	.00579	1.652	.04402
75.00	4.4561	100.26	9.7250	.43222	9.8871	.43943	.14499	.00644	1.640	.04980
80.00	4.2588	95.622	10.855	.48245	11.035	.49044	.16038	.00713	1.629	.05576
90.00	3.9234	88.276	13.267	.58964	13.484	.59928	.19280	.00857	1.610	.06813



## OSMIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GH/CH2	CH	PROTON PATH LENGTH GH/CH2	CH	PATH LENGTH STRAGGLING GH/CH2	CM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	3.6502	82.130	15.869	16.126	.71671	.22727	.01010	1.409	1.594	.08103
110.00	3.4218	76.989	18.658	18.957	.84254	.26363	.01172	1.391	1.521	.09443
120.00	3.2280	72.630	21.623	21.948	.97636	.30183	.01341	1.374	1.570	.10833
130.00	3.0614	68.861	24.758	25.150	1.1178	.34171	.01519	1.359	1.560	.12266
140.00	2.9167	65.025	28.053	28.495	1.2664	.38320	.01703	1.345	1.552	.13735
150.00	2.7897	62.768	31.507	32.002	1.4223	.42622	.01894	1.332	1.545	.15234
160.00	2.6774	60.242	35.113	35.661	1.5850	.47068	.02092	1.320	1.538	.16762
170.00	2.5774	57.992	38.864	39.469	1.7542	.51651	.02296	1.309	1.532	.18320
180.00	2.4878	55.976	42.755	43.418	1.9297	.56364	.02505	1.298	1.527	.19903
190.00	2.4071	54.159	46.782	47.505	2.1113	.61201	.02720	1.288	1.522	.21507
200.00	2.3339	52.512	50.940	51.725	2.2989	.66156	.02940	1.279	1.518	.23126
210.00	2.2695	51.064	55.223	56.072	2.4921	.71217	.03165	1.270	1.514	.24753
220.00	2.2085	49.691	59.620	60.534	2.6904	.76377	.03395	1.262	1.510	.26381
230.00	2.1525	48.432	64.144	65.126	2.8945	.81640	.03628	1.254	1.507	.28007
240.00	2.1010	47.273	68.768	69.819	3.1031	.87002	.03867	1.246	1.504	.29627
250.00	2.0535	46.203	73.516	74.636	3.3172	.92457	.04109	1.239	1.502	.31239
260.00	2.0095	45.213	78.370	79.562	3.5361	.98001	.04356	1.232	1.499	.32841
270.00	1.9686	44.294	83.326	84.592	3.7697	1.0363	.04606	1.225	1.497	.34433
280.00	1.9306	43.439	88.385	89.726	3.9876	1.0934	.04860	1.219	1.494	.36011
290.00	1.8952	42.642	93.453	94.956	4.2203	1.1513	.05117	1.212	1.492	.37574
300.00	1.8621	41.897	98.769	100.26	4.4562	1.2100	.05378	1.207	1.490	.39120
310.00	1.8301	41.178	104.11	105.68	4.6970	1.2693	.05642	1.201	1.489	.40653
320.00	1.8010	40.523	109.54	111.20	4.9421	1.3285	.05909	1.196	1.487	.42177
330.00	1.7736	39.907	115.06	116.79	5.1907	1.3902	.06179	1.190	1.485	.43690
340.00	1.7479	39.328	120.65	122.47	5.4431	1.4517	.06452	1.185	1.484	.45189
350.00	1.7237	38.782	126.33	128.23	5.6991	1.5137	.06727	1.180	1.482	.46674
360.00	1.7007	38.267	132.08	134.07	5.9586	1.5762	.07005	1.176	1.481	.48142
370.00	1.6791	37.780	137.97	140.04	6.2239	1.6394	.07286	1.171	1.479	.49592
380.00	1.6586	37.318	143.87	146.03	6.4903	1.7030	.07569	1.166	1.478	.51022
390.00	1.6392	36.881	149.85	152.10	6.7593	1.7672	.07854	1.162	1.476	.52431
400.00	1.6207	36.466	155.86	158.20	7.0309	1.8318	.08142	1.158	1.476	.53818
410.00	1.6032	36.072	161.96	164.38	7.3059	1.8970	.08431	1.154	1.474	.55183
420.00	1.5865	35.697	168.14	170.65	7.5845	1.9625	.08722	1.150	1.473	.56523
430.00	1.5707	35.340	174.38	176.99	7.8660	2.0285	.09016	1.146	1.472	.57839
440.00	1.5556	35.001	180.68	183.38	8.1503	2.0950	.09311	1.142	1.471	.59130
450.00	1.5412	34.677	187.05	189.84	8.4373	2.1618	.09608	1.137	1.470	.60395
460.00	1.5274	34.367	193.47	196.35	8.7269	2.2290	.09907	1.134	1.469	.61634
470.00	1.5143	34.072	199.95	202.93	9.0191	2.2966	.10207	1.132	1.469	.62846
480.00	1.5017	33.789	206.48	209.56	9.3137	2.3645	.10509	1.128	1.468	.64032
490.00	1.4897	33.519	213.07	216.24	9.6108	2.4328	.10813	1.125	1.467	.65192

OSMIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.4782	33.201	219.71	9.7649	2.5014	.11117	1.122	.66325
510.00	1.4672	33.013	226.40	10.062	2.5704	.11424	1.119	.67431
520.00	1.4567	32.775	233.14	10.362	2.6396	.11732	1.116	.68510
530.00	1.4465	32.548	239.96	10.665	2.7092	.12041	1.112	.69562
540.00	1.4369	32.329	246.80	10.969	2.7790	.12351	1.110	.70588
550.00	1.4275	32.119	253.68	11.275	2.8491	.12663	1.107	.71587
560.00	1.4186	31.918	260.61	11.582	2.9195	.12976	1.104	.72561
570.00	1.4100	31.724	267.57	11.892	2.9901	.13289	1.101	.73508
580.00	1.4017	31.538	274.59	12.204	3.0610	.13605	1.099	.74429
590.00	1.3937	31.359	281.64	12.517	3.1321	.13921	1.096	.75325
600.00	1.3860	31.186	288.73	12.832	3.2035	.14238	1.093	.76195
620.00	1.3715	30.860	303.03	13.468	3.3469	.14875	1.088	.77863
640.00	1.3581	30.557	317.47	14.110	3.4911	.15516	1.084	.79433
660.00	1.3455	30.275	332.06	14.758	3.6361	.16161	1.079	.80911
680.00	1.3339	30.012	346.77	15.412	3.7819	.16808	1.075	.82288
700.00	1.3230	29.767	361.65	16.073	3.9283	.17459	1.070	.83600
720.00	1.3128	29.538	376.75	16.745	4.0754	.18113	1.066	.84819
740.00	1.3033	29.324	391.83	17.415	4.2231	.18770	1.062	.85959
760.00	1.2944	29.123	407.02	18.090	4.3714	.19429	1.058	.87024
780.00	1.2860	28.935	422.31	18.769	4.5203	.20090	1.055	.88017
800.00	1.2782	28.759	437.71	19.454	4.6696	.20754	1.051	.88943
820.00	1.2708	28.594	453.19	20.142	4.8194	.21420	1.048	.89805
840.00	1.2639	28.438	468.76	20.834	4.9697	.22088	1.045	.90606
860.00	1.2574	28.292	484.41	21.529	5.1204	.22757	1.042	.91351
880.00	1.2513	28.155	500.15	22.229	5.2715	.23429	1.039	.92042
900.00	1.2456	28.026	515.97	22.932	5.4230	.24102	1.036	.92682
920.00	1.2402	27.904	531.87	23.639	5.5749	.24777	1.033	.93276
940.00	1.2351	27.790	547.84	24.349	5.7271	.25454	1.030	.93825
960.00	1.2303	27.682	563.90	25.062	5.8797	.26132	1.028	.94332
1000.00	1.2215	27.484	596.40	26.506	6.1857	.27492	1.022	.95230

THE ELECTRON DENSITY OF OSMIUM IS 2.407E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.929 BEV, AND THE MINIMUM ENERGY LOSS IS 1.1570 MEV/GM/CM2

# OXYGEN (DIATOMIC)

ELEMENT NUMBER 8  
 ATOMIC NUMBER 8  
 ATOMS/MOLECULE 2  
 ADJUSTED ATOMIC WEIGHT 15.999  
 IONIZATION POTENTIAL 88.90

DENSITY = 1.4290 MG/CM3

FRCION ENERGY MEV	ENERGY LOSS KEV/CM	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		MG/CM2	METER	MG/CM2	METER	MG/CM2	METER PERCENT		
.10	610.76	16607	.00116	.16750	.00117	.00585	.00004	.8995	0.
.15	600.68	24849	.00174	.25013	.00175	.00779	.00005	.6536	0.
.20	543.55	33570	.00235	.33758	.00236	.00950	.00007	.5575	0.
.30	450.79	53741	.00376	.53994	.00378	.01340	.00009	.4683	0.
.40	381.69	77832	.00545	.78163	.00547	.01840	.00013	.4231	0.
.50	334.64	10580	.00740	1.0621	.00743	.02427	.00017	.3945	0.
.60	301.66	13721	.00960	1.3772	.00964	.03066	.00021	.3741	0.
.70	271.73	17201	.01204	1.7263	.01208	.03759	.00026	.356	0.
.80	252.03	21012	.01470	2.1085	.01476	.04498	.00031	.33	0.
.90	237.50	25085	.01755	2.5170	.01761	.05254	.00037	.336	0.
1.00	222.95	29420	.02059	2.9517	.02066	.06029	.00042	.371	0.
1.20	196.26	38976	.02728	3.9099	.02736	.07714	.00054	.3124	0.
1.40	175.97	49731	.03480	4.9881	.03491	.09579	.00067	.3008	0.
1.60	159.94	61641	.04314	6.1821	.04326	.11609	.00081	.2913	.00001
1.80	146.92	74669	.05225	7.4882	.05240	.13793	.00097	.2834	.00001
2.00	136.11	88792	.06214	8.9038	.06231	.16121	.00113	.2767	.00002
2.20	126.98	10398	.07276	10.426	.07296	.18589	.00130	.2709	.00003
2.40	119.13	12021	.08412	12.053	.08435	.21191	.00148	.2659	.00005
2.60	112.31	13747	.09620	13.783	.09645	.23923	.00167	.2615	.00007
2.80	106.32	15574	.10898	15.614	.10927	.26781	.00187	.2575	.00008
3.00	101.00	17500	.12246	17.545	.12278	.29764	.00208	.2540	.00011
3.20	96.249	19525	.13663	19.574	.13698	.32869	.00230	.2508	.00013
3.40	91.973	21647	.15148	21.700	.15186	.36094	.00253	.2479	.00015
3.60	88.100	23865	.16700	23.923	.16741	.39437	.00276	.2453	.00018
3.80	84.575	26177	.18318	26.240	.18363	.42896	.00300	.2429	.00021
4.00	81.350	28583	.20002	28.652	.20050	.46471	.00325	.2406	.00024
4.20	78.387	31083	.21752	31.157	.21804	.50160	.00351	.2385	.00028
4.40	75.654	33675	.23565	33.755	.23621	.53961	.00378	.2366	.00031
4.60	73.124	36359	.25443	36.444	.25503	.57874	.00405	.2348	.00035
4.80	70.775	39133	.27385	39.225	.27449	.61898	.00433	.2331	.00039

# OXYGEN (DIATOMIC)

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	68.588	0.4200	0.4210	0.0066	2315	.00043
5.50	63.721	0.4955	0.4966	0.0077	2279	.00055
6.00	59.559	0.5766	0.5779	0.0088	2248	.00068
6.50	55.955	0.6630	0.6645	0.0100	2221	.00084
7.00	52.800	0.7549	0.7566	0.0113	2196	.00225
7.50	49.960	0.8521	0.8540	0.0127	2174	.00458
8.00	47.491	0.9546	0.9567	0.0141	2154	.00650
8.50	45.275	1.0621	1.0644	0.0155	2136	.00922
9.00	43.276	1.1750	1.1774	0.0171	2120	.01155
9.50	41.462	1.2928	1.2956	0.0186	2104	.01357
10.00	39.807	1.4157	1.4187	0.0203	2090	.01619
11.00	36.898	1.6763	1.6798	0.0237	2065	.02084
12.00	34.421	1.9566	1.9606	0.0274	2043	.02549
13.00	32.284	2.2562	2.2608	0.0313	2024	.03016
14.00	30.420	2.5749	2.5800	0.0355	2007	.03483
15.00	28.779	2.9123	2.9181	0.0398	1991	.03951
16.00	27.323	3.2684	3.2740	0.0443	1977	.04420
17.00	26.020	3.6429	3.6500	0.0491	1964	.04890
18.00	24.849	4.0356	4.0435	0.0541	1953	.05361
19.00	23.708	4.4462	4.4549	0.0592	1942	.05833
20.00	22.624	4.8747	4.8841	0.0646	1932	.06306
21.00	21.134	5.7844	5.7955	0.0759	1915	.07254
22.00	19.700	6.7636	6.7765	0.0880	1899	.08206
23.00	18.468	7.8108	7.8256	0.1008	1885	.08785
24.00	17.397	8.9252	8.9419	0.1143	1873	.08980
25.00	16.457	1.0106	1.0124	0.1286	1862	.09183
26.00	15.624	1.1351	1.1372	0.1435	1852	.09393
27.00	14.881	1.2661	1.2684	0.1592	1843	.09609
28.00	14.214	1.4034	1.4060	0.1755	1835	.09832
29.00	13.612	1.5470	1.5498	0.1925	1828	.10059
30.00	13.065	1.6967	1.6998	0.2101	1821	.10291
31.00	11.895	2.0976	2.1014	0.2569	1805	.10890
32.00	10.942	2.5356	2.5402	0.3075	1792	.11507
33.00	10.150	3.0097	3.0150	0.3618	1781	.12148
34.00	9.4808	3.5189	3.5251	0.4197	1771	.12818
35.00	8.9078	4.0623	4.0695	0.4809	1763	.13514
36.00	8.4112	4.6393	4.6475	0.5455	1755	.14232
37.00	7.9765	5.2490	5.2582	0.6133	1748	.14970
38.00	7.5928	5.8966	5.9009	0.6842	1742	.15723
39.00	6.9456	7.2672	7.2798	0.8349	1731	.17266

## OXYGEN (DIATOMIC)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	METER	GM/CM2	METER	GM/CM2	METER PERCENT		
100.00	6.4205	8.7637	61.327	8.7788	61.433	.09969	.69760	1.136	.18840
110.00	5.9856	10.375	72.606	10.393	72.731	.11696	.81847	1.125	.20448
120.00	5.6195	12.098	84.661	12.119	84.805	.13524	.94642	1.116	.22097
130.00	5.3068	13.927	97.461	13.951	97.627	.15449	1.0811	1.107	.23776
140.00	5.0367	15.859	110.98	15.886	111.17	.17464	1.2221	1.099	.25473
150.00	4.8010	17.890	125.19	17.921	125.41	.19566	1.3692	1.092	.27179
160.00	4.5934	20.017	140.08	20.051	140.31	.21751	1.5221	1.085	.28893
170.00	4.4093	22.236	155.61	22.274	155.87	.24014	1.6805	1.078	.30617
180.00	4.2449	24.544	171.76	24.586	172.05	.26352	1.8441	1.072	.32343
190.00	4.0971	26.939	188.52	26.984	188.83	.28761	2.0127	1.066	.34066
200.00	3.9636	29.417	205.86	29.466	206.20	.31238	2.1860	1.060	.35781
210.00	3.8424	31.976	223.76	32.029	224.14	.33781	2.3640	1.055	.37485
220.00	3.7320	34.613	242.22	34.670	242.62	.36386	2.5463	1.049	.39181
230.00	3.6308	37.325	261.20	37.388	261.63	.39051	2.7327	1.044	.40862
240.00	3.5380	40.111	280.70	40.178	281.16	.41772	2.9232	1.040	.42527
250.00	3.4524	42.968	300.69	43.040	301.19	.44549	3.1175	1.035	.44171
260.00	3.3732	45.894	321.16	45.970	321.70	.47378	3.3155	1.031	.45798
270.00	3.2999	48.887	342.11	48.968	342.67	.50257	3.5170	1.026	.47411
280.00	3.2317	51.945	363.50	52.031	364.11	.53185	3.7218	1.022	.49006
290.00	3.1682	55.065	385.54	55.156	385.98	.56159	3.9300	1.018	.50581
300.00	3.1088	58.247	407.61	58.343	408.28	.59178	4.1412	1.014	.52135
310.00	3.0533	61.488	430.28	61.580	430.99	.62239	4.3555	1.011	.53667
320.00	3.0013	64.786	453.37	64.893	454.11	.65342	4.5726	1.007	.55177
330.00	2.9524	68.140	476.84	68.252	477.62	.68484	4.7925	1.003	.56665
340.00	2.9064	71.549	500.69	71.666	501.51	.71665	5.0150	1.000	.58127
350.00	2.8631	75.010	524.91	75.133	525.77	.74882	5.2402	.9967	.59563
360.00	2.8222	78.522	549.49	78.651	550.39	.78135	5.4678	.9934	.60977
370.00	2.7835	82.085	574.42	82.219	575.36	.81421	5.6978	.9903	.62372
380.00	2.7470	85.696	599.69	85.836	600.67	.84741	5.9301	.9872	.63747
390.00	2.7123	89.354	625.29	89.499	626.31	.88092	6.1646	.9843	.65099
400.00	2.6794	93.057	651.21	93.209	652.27	.91474	6.4012	.9814	.66427
410.00	2.6482	96.806	677.44	96.963	678.54	.94885	6.6400	.9786	.67725
420.00	2.6185	100.60	703.97	100.76	705.12	.98325	6.8807	.9758	.68985
430.00	2.5902	104.43	730.80	104.60	731.99	1.0179	7.1233	.9731	.70207
440.00	2.5632	108.31	757.92	108.48	759.15	1.0529	7.3678	.9705	.71393
450.00	2.5375	112.22	785.31	112.40	786.59	1.0881	7.6141	.9680	.72541
460.00	2.5130	116.1	812.98	116.36	814.30	1.1235	7.8621	.9655	.73653
470.00	2.4896	120.11	840.92	120.36	842.28	1.1592	8.1118	.9631	.74729
480.00	2.4672	124.20	869.11	124.40	870.52	1.1951	8.3632	.9607	.75769
490.00	2.4457	128.26	897.55	128.47	899.00	1.2312	8.6161	.9584	.76774

# OXYGEN (DIATOMIC)

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/CH2	KEV/CH	GH/CH2	METER	GH/CH2	METER	GM/CH2	METER		
500.00	2.4232	3.4656	132.36	926.24	132.57	927.74	1.2676	8.0705	.1613	.77744
510.00	2.4055	3.4375	136.49	955.17	136.71	956.71	1.3042	9.1264	.1611	.78681
520.00	2.3867	3.4105	140.66	984.33	140.89	985.92	1.3439	9.3838	.1610	.79584
530.00	2.3686	3.3847	144.86	1013.7	145.09	1015.4	1.3779	9.6425	.1608	.80454
540.00	2.3512	3.3598	149.09	1043.3	149.33	1045.0	1.4151	9.9026	.1607	.81292
550.00	2.3345	3.3360	153.35	1073.2	153.60	1074.9	1.4524	10.164	.1605	.82099
560.00	2.3184	3.3130	157.65	1103.2	157.90	1105.0	1.4900	10.427	.1604	.82876
570.00	2.3030	3.2910	161.97	1133.4	162.23	1135.2	1.5277	10.690	.1602	.83623
580.00	2.2881	3.2697	166.32	1163.9	166.58	1165.7	1.5655	10.956	.1601	.84342
590.00	2.2738	3.2493	170.69	1194.5	170.97	1196.4	1.6036	11.222	.1599	.85112
600.00	2.2601	3.2295	175.10	1225.3	175.38	1227.3	1.6418	11.489	.1598	.85696
620.00	2.2340	3.1923	183.99	1287.5	184.28	1289.6	1.7187	12.027	.1595	.86944
640.00	2.2097	3.1576	192.97	1350.4	193.28	1352.6	1.7961	12.569	.1592	.88093
660.00	2.1871	3.1253	202.06	1414.0	202.38	1416.2	1.8741	13.115	.1589	.89149
680.00	2.1659	3.0951	211.23	1478.7	211.57	1480.5	1.9527	13.665	.1586	.90119
700.00	2.1462	3.0669	220.50	1543.3	220.85	1545.5	2.0317	14.218	.1583	.91008
720.00	2.1277	3.0405	229.84	1608.4	230.21	1611.0	2.1112	14.774	.1580	.91822
740.00	2.1104	3.0157	239.27	1674.4	239.65	1677.0	2.1912	15.334	.1577	.92567
760.00	2.0941	2.9924	248.77	1740.9	249.16	1743.6	2.2716	15.896	.1574	.93247
780.00	2.0788	2.9706	258.34	1807.8	258.75	1810.7	2.3524	16.462	.1571	.93869
800.00	2.0644	2.9501	267.98	1875.3	268.40	1878.2	2.4336	17.030	.1568	.94435
820.00	2.0509	2.9307	277.69	1943.2	278.12	1946.3	2.5152	17.601	.1565	.94952
840.00	2.0381	2.9125	287.46	2011.6	287.91	2014.7	2.5971	18.174	.1562	.95422
860.00	2.0261	2.8953	297.29	2080.4	297.75	2083.6	2.6794	18.750	.1559	.95850
880.00	2.0147	2.8791	307.17	2149.6	307.65	2152.9	2.7620	19.328	.1556	.96240
900.00	2.0040	2.8637	317.12	2219.1	317.61	2222.6	2.8449	19.908	.1553	.96594
920.00	1.9939	2.8492	327.11	2289.1	327.62	2292.7	2.9281	20.491	.1550	.96915
940.00	1.9843	2.8355	337.17	2359.5	337.69	2363.1	3.0116	21.075	.1547	.97207
960.00	1.9752	2.8225	347.27	2430.2	347.81	2433.9	3.0954	21.661	.1543	.97472
1000.00	1.9584	2.7986	367.71	2573.2	368.28	2577.2	3.2638	22.840	.1535	.97934

THE ELECTRON DENSITY OF OXYGEN (DIATOMIC) IS 3.013E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.272 BEV, AND THE MINIMUM ENERGY LOSS IS 1.8137 MEV/GM/CM2

# PLATINUM

ATOMIC NUMBER 78  
ELEMENT PT  
ATOMS/MOLECULE 1  
ATOMIC WEIGHT 195.09  
ADJUSTED IONIZATION POTENTIAL 771.0

DENSITY = 21.450 GM/CM3

PRCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/CM	HEV/CM	MG/CM2	MM	MG/CM2	MM	MG/CM2	MM		
.10	107.83	2313.1	1.2351	.00058	1.3033	.00061	.06630	.00003	5.238	0.
.15	117.67	2524.0	1.6729	.00078	1.7471	.00081	.08384	.00004	4.243	0.
.20	119.34	2559.8	2.0831	.00097	2.1689	.00101	.09657	.00005	3.956	0.
.30	110.74	2375.3	2.9189	.00136	3.0343	.00141	.12292	.00006	3.803	0.
.40	98.334	2109.3	3.8423	.00179	3.9924	.00186	.15306	.00007	3.760	0.
.50	85.223	1892.4	4.8785	.00227	5.0677	.00236	.18765	.00009	3.734	0.
.60	80.974	1736.9	6.0261	.00261	6.2525	.00291	.22533	.00011	3.709	0.
.70	75.180	1612.6	7.2565	.00338	7.5340	.00351	.26489	.00012	3.683	0.
.80	69.864	1498.6	8.5873	.00400	8.9130	.00416	.30648	.00014	3.655	0.
.90	67.021	1437.6	9.9973	.00466	10.373	.00484	.34897	.00016	3.626	0.
1.00	64.178	1376.6	11.471	.00535	11.899	.00555	.39110	.00018	3.595	0.
1.20	59.884	1284.5	14.591	.00680	15.125	.00705	.47487	.00022	3.531	0.
1.40	56.086	1203.1	17.933	.00836	18.577	.00866	.56107	.00026	3.466	0.
1.60	52.754	1131.6	21.500	.01002	22.257	.01038	.65265	.00030	3.402	0.
1.80	49.825	1068.8	25.238	.01179	26.161	.01220	.74874	.00035	3.339	0.
2.00	47.255	1013.6	29.290	.01366	30.283	.01412	.84882	.00040	3.280	0.
2.20	44.973	964.68	33.506	.01562	34.622	.01614	.95249	.00044	3.223	0.
2.40	42.933	920.92	37.934	.01769	39.176	.01826	1.0595	.00049	3.170	0.
2.60	41.098	881.54	42.568	.01945	43.939	.02048	1.1698	.00055	3.120	0.
2.80	39.424	845.64	47.406	.02210	48.909	.02280	1.2833	.00060	3.074	0.
3.00	37.917	813.33	52.444	.02445	54.083	.02521	1.3997	.00065	3.030	0.
3.20	36.539	783.76	57.680	.02689	59.457	.02772	1.5191	.00071	2.989	0.
3.40	35.277	756.69	63.110	.02942	65.028	.03032	1.6414	.00077	2.950	0.
3.60	34.115	731.77	68.733	.03204	70.796	.03301	1.7663	.00082	2.914	0.
3.80	33.041	708.74	74.544	.03475	76.754	.03578	1.8940	.00088	2.879	0.
4.00	32.045	687.36	80.541	.03755	82.901	.03865	2.0243	.00094	2.847	0.
4.20	31.116	667.44	86.722	.04043	89.236	.04160	2.1572	.00101	2.816	0.
4.40	30.247	648.80	93.086	.04340	95.756	.04464	2.2926	.00107	2.787	0.
4.60	29.433	631.35	99.630	.04645	102.46	.04777	2.4306	.00113	2.760	0.
4.80	28.674	615.05	106.36	.04958	109.35	.05098	2.5712	.00120	2.734	0.

PLATINUM

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PAYH LENGTH STRAGGLING GM/CM2	PAYH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	27.937	11326	11642	.00543	.00271	.00013	2.709	0.
5.50	26.349	13127	13485	.00612	.00308	.00014	2.652	0.
6.00	25.104	15035	15437	.00701	.00346	.00016	2.601	0.
6.50	23.852	17029	17476	.00794	.00386	.00018	2.556	.00001
7.00	22.739	19130	19623	.00892	.00427	.00020	2.515	.00001
7.50	21.744	21334	21876	.00995	.00470	.00022	2.477	.00002
8.00	20.846	23628	24219	.01102	.00514	.00024	2.443	.00003
8.50	20.034	26032	26675	.01214	.00561	.00026	2.410	.00003
9.00	19.286	28522	29217	.01330	.00608	.00028	2.381	.00003
9.50	18.617	31107	31857	.01465	.00657	.00031	2.354	.00004
10.00	17.998	33787	34593	.01613	.00708	.00033	2.328	.00004
11.00	16.896	39400	40321	.01880	.00812	.00038	2.283	.00006
12.00	15.941	45383	46425	.02116	.00922	.00043	2.243	.00008
13.00	15.107	51780	52867	.02410	.01036	.00048	2.207	.00012
14.00	14.368	58359	59656	.02721	.01154	.00054	2.175	.00018
15.00	13.710	65353	66767	.03047	.01277	.00060	2.146	.00026
16.00	13.119	72674	74248	.03388	.01404	.00065	2.120	.00036
17.00	12.584	80313	82032	.03744	.01535	.00072	2.096	.00048
18.00	12.098	88266	90135	.04115	.01670	.00078	2.074	.00063
19.00	11.654	96537	98561	.04501	.01809	.00084	2.054	.00080
20.00	11.246	10511	10730	.04900	.01952	.00091	2.035	.00099
22.00	10.524	12318	12570	.05743	.02250	.00105	2.001	.00143
24.00	9.9020	14244	14530	.06640	.02562	.00119	1.972	.00197
26.00	9.3598	16285	16609	.07592	.02888	.00135	1.946	.00293
28.00	8.8805	18442	18803	.08598	.03229	.00151	1.922	.00432
30.00	8.4827	20710	21111	.09655	.03582	.00167	1.902	.00576
32.00	8.1044	23083	23525	.10761	.03947	.00184	1.883	.00726
34.00	7.7645	25540	26046	.11916	.04324	.00202	1.866	.00881
36.00	7.4564	28142	28672	.13120	.04714	.00220	1.850	.01041
38.00	7.1745	30831	31407	.14373	.05115	.00238	1.835	.01205
40.00	6.9188	33625	34249	.15676	.05531	.00258	1.822	.01374
45.00	6.3643	41045	41794	.19135	.06624	.00309	1.792	.01816
50.00	5.9061	49069	49952	.23286	.07791	.00363	1.758	.02281
55.00	5.5201	57694	58720	.26897	.09030	.00421	1.746	.02770
60.00	5.1900	66891	68067	.31185	.10336	.00482	1.728	.03283
65.00	4.9045	76646	77981	.35733	.11707	.00546	1.712	.03819
70.00	4.6551	86946	88448	.40534	.13140	.00613	1.698	.04377
75.00	4.4352	97754	99430	.45573	.14633	.00682	1.685	.04953
80.00	4.2394	10910	11096	.50865	.16183	.00754	1.674	.05547
90.00	3.9064	13332	13556	.62153	.19449	.00907	1.654	.06781



PLATINUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CH	PROTON RANGE GH/CH2	PROTON PATH LENGTH GH/CH2	GH/CH2	PATH LENGTH STRAGGLING CH	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	3.6337	77.943	15.944	16.209	.75568	.2923	.08066
110.00	3.4068	73.076	18.744	19.033	.68827	.01240	.09406
120.00	3.2141	68.942	21.721	22.077	1.0292	.01419	.10793
130.00	3.0485	65.391	24.868	25.273	1.1782	.01606	.12223
140.00	2.9046	62.303	28.178	28.635	1.3349	.01801	.13689
150.00	2.7783	59.595	31.643	32.153	1.4990	.02003	.15184
160.00	2.666	57.200	35.261	35.827	1.6702	.0212	.16708
170.00	2.5672	55.067	39.026	39.485	1.8485	.02427	.18262
180.00	2.4781	53.155	42.931	43.615	2.0333	.02648	.19841
190.00	2.3978	51.432	46.971	47.717	2.2246	.02875	.21440
200.00	2.3250	49.871	51.144	51.953	2.4221	.03108	.23055
210.00	2.2610	48.499	55.442	56.317	2.6255	.03345	.24677
220.00	2.2003	47.196	59.856	60.799	2.8345	.03587	.26298
230.00	2.1446	46.002	64.394	65.406	3.0492	.03834	.27916
240.00	2.0934	44.903	69.027	70.139	3.2695	.04086	.29527
250.00	2.0461	43.888	73.794	74.949	3.4941	.04342	.31129
260.00	2.0023	42.949	78.663	79.823	3.7246	.04602	.32722
270.00	1.9616	42.077	83.536	84.941	3.9600	.04866	.34308
280.00	1.9238	41.265	88.710	90.022	4.2001	.05134	.35884
290.00	1.8885	40.509	93.881	95.341	4.4448	.05405	.37448
300.00	1.8556	39.802	99.126	100.67	4.6932	.05660	.38998
310.00	1.8247	39.139	104.48	106.110	4.9465	.05959	.40536
320.00	1.7958	38.498	109.93	111.63	5.2042	.06240	.42065
330.00	1.7676	37.914	115.46	117.25	5.4663	.06525	.43584
340.00	1.7419	37.364	121.08	122.95	5.7320	.06813	.45089
350.00	1.7177	36.845	126.77	128.73	6.0014	.07104	.46580
360.00	1.6949	36.357	132.54	134.59	6.2746	.07398	.48053
370.00	1.6734	35.894	138.39	140.53	6.5513	.07694	.49505
380.00	1.6530	35.456	144.37	146.60	6.8343	.07992	.50936
390.00	1.6336	35.042	150.37	152.68	7.1180	.08293	.52343
400.00	1.6153	34.648	156.43	158.84	7.4050	.08596	.53727
410.00	1.5979	34.274	162.52	165.02	7.6933	.08902	.55087
420.00	1.5813	33.918	168.70	171.30	7.9858	.09209	.56424
430.00	1.5655	33.580	174.96	177.65	8.2821	.09518	.57736
440.00	1.5505	33.257	181.29	184.07	8.5813	.09830	.59023
450.00	1.5361	32.950	187.67	190.35	8.8833	.10143	.60285
460.00	1.5224	32.654	194.11	197.08	9.1881	.10458	.61521
470.00	1.5094	32.376	200.61	203.68	9.4955	.10775	.62731
480.00	1.4969	32.103	207.16	210.33	9.8056	.11094	.63915
490.00	1.4849	31.852	213.77	217.04	10.118	.11414	.65072

# PLATINUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH GM/CM2 CM		PATH LENGTH STRAGGLING GM/CM2 CM PERCENT		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM PERCENT		
500.00	1.4735	220.43	10.276	283.79	10.433	2.5173	1.1735	1.505	.66203
510.00	1.4625	227.14	10.589	290.60	10.751	2.5866	1.2059	1.504	.67307
520.00	1.4520	233.90	10.904	297.46	11.071	2.6562	1.2383	1.503	.68385
530.00	1.4420	240.70	11.222	304.37	11.393	2.7251	1.2709	1.502	.69436
540.00	1.4323	247.56	11.541	311.33	11.717	2.7963	1.3037	1.501	.70461
550.00	1.4230	254.49	11.864	318.37	12.045	2.8668	1.3365	1.501	.71460
560.00	1.4141	261.44	12.188	325.42	12.374	2.9376	1.3695	1.500	.72432
570.00	1.4055	268.42	12.514	332.51	12.704	3.0086	1.4026	1.499	.73379
580.00	1.3973	275.45	12.842	339.64	13.037	3.0799	1.4358	1.498	.74300
590.00	1.3894	282.53	13.171	346.82	13.372	3.1514	1.4692	1.497	.75196
600.00	1.3817	289.64	13.503	354.04	13.708	3.2231	1.5026	1.496	.76067
620.00	1.3673	303.97	14.171	368.59	14.386	3.3673	1.5698	1.495	.77735
640.00	1.3539	318.46	14.846	383.28	15.072	3.5123	1.6374	1.493	.79307
660.00	1.3414	333.08	15.528	398.12	15.763	3.6581	1.7054	1.492	.80786
680.00	1.3298	347.87	16.218	413.14	16.463	3.8046	1.7737	1.491	.82176
700.00	1.3190	362.89	16.918	428.37	17.174	3.9518	1.8423	1.488	.83480
720.00	1.3088	377.90	17.630	443.61	17.884	4.0996	1.9113	1.486	.84702
740.00	1.2994	393.03	18.353	458.95	18.599	4.2481	1.9805	1.485	.85845
760.00	1.2905	408.26	19.033	474.41	19.320	4.3972	2.0504	1.484	.86913
780.00	1.2822	423.59	19.748	489.96	20.043	4.5458	2.1197	1.482	.87921
800.00	1.2744	439.02	20.467	505.62	20.775	4.6960	2.1897	1.481	.88840
820.00	1.2671	454.54	21.191	521.37	21.509	4.8474	2.2599	1.479	.89766
840.00	1.2602	470.15	21.919	537.20	22.247	4.9965	2.3303	1.478	.90512
860.00	1.2538	485.85	22.650	553.13	22.990	5.1499	2.4009	1.476	.91280
880.00	1.2477	501.63	23.386	569.13	23.736	5.3018	2.4717	1.475	.91955
900.00	1.2420	517.48	24.125	585.22	24.486	5.4541	2.5427	1.473	.92600
920.00	1.2366	533.42	24.868	601.38	25.239	5.6067	2.6138	1.471	.93197
940.00	1.2316	549.44	25.615	617.63	25.997	5.7596	2.6851	1.469	.93750
960.00	1.2268	565.54	26.365	633.95	26.758	5.9129	2.7566	1.467	.94261
1000.00	1.2186	598.11	27.884	666.97	28.297	6.2205	2.9000	1.460	.95166

THE ELECTRON DENSITY OF PLATINUM IS 2.409E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.925 BEV, AND THE MINIMUM ENERGY LOSS IS 1.1530 MEV/GM/CM2

# RADIUM

ELEMENT NUMBER 88  
 ATOMIC WEIGHT 226.11  
 ADJUSTED IONIZATION POTENTIAL 69.1  
 ATOMS/MOLECULE 1  
 DENSITY \* 5.0000 GM/CM3

DENSITY \* 5.0000 GM/CM3

PROCTON ENERGY MEV	ENERGY LOSS GM/CM2	PROCTON RANGE	PROCTON PATH LENGTH MM	HG/CM2	PROCTON PATH LENGTH MM	HG/CM2	PATH LENGTH STRAGGLING MM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	119.24	596.20	1.3778	.00276	1.4620	.00292	.07560	.00015	5.171	0.
.15	124.73	623.64	1.7832	.00357	1.8719	.00374	.08642	.00018	4.739	0.
.20	123.36	616.79	2.1763	.00435	2.2750	.00455	.09920	.00020	4.336	0.
.30	110.71	553.55	3.0015	.00600	3.1374	.00625	.12069	.00024	4.028	0.
.40	97.624	488.12	3.9510	.00786	4.0909	.00818	.14737	.00029	3.908	0.
.50	88.337	441.69	4.9705	.00994	5.1693	.01034	.18083	.00036	3.846	0.
.60	80.829	404.14	6.1116	.01222	6.3533	.01271	.21850	.00044	3.804	0.
.70	75.392	376.96	7.3463	.01469	7.6341	.01527	.25880	.00052	3.770	0.
.80	69.442	347.21	8.6792	.01736	9.0162	.01803	.30193	.00060	3.738	0.
.90	65.538	327.69	10.108	.02022	10.497	.02099	.34764	.00070	3.708	0.
1.00	61.624	308.12	11.627	.02325	12.072	.02414	.39513	.00079	3.680	0.
1.20	56.335	281.68	14.909	.02982	15.470	.03094	.49402	.00099	3.626	0.
1.40	52.123	260.62	18.479	.03696	19.164	.03833	.59578	.00119	3.576	0.
1.60	48.665	243.33	22.323	.04465	22.140	.04628	.70042	.00140	3.527	0.
1.80	45.758	228.79	26.429	.05286	27.383	.05477	.80796	.00162	3.481	0.
2.00	43.254	216.27	30.783	.06157	31.879	.06376	.92082	.00184	3.437	0.
2.20	41.085	205.43	35.381	.07076	36.624	.07325	1.0398	.00208	3.394	0.
2.40	39.169	195.85	40.217	.08043	41.613	.08323	1.1640	.00233	3.354	0.
2.60	37.463	187.31	45.283	.09057	46.837	.09367	1.2928	.00259	3.316	0.
2.80	35.932	179.66	50.574	.10115	52.289	.10458	1.4256	.00285	3.280	0.
3.00	34.605	173.02	56.080	.11216	57.961	.11592	1.5614	.00312	3.246	0.
3.20	33.352	166.76	61.796	.12359	63.848	.12770	1.7012	.00340	3.213	0.
3.40	32.209	161.05	67.723	.13545	69.945	.13990	1.8440	.00369	3.182	0.
3.60	31.158	155.79	73.863	.14773	76.268	.15254	1.9898	.00398	3.153	0.
3.80	30.187	150.93	80.205	.16041	82.792	.16556	2.1386	.00428	3.125	0.
4.00	29.236	146.18	86.741	.17348	89.514	.17953	2.2903	.00458	3.098	0.
4.20	28.434	142.17	93.493	.18699	96.456	.19291	2.4454	.00489	3.072	0.
4.40	27.681	138.40	100.43	.20086	103.59	.20717	2.6027	.00521	3.048	0.
4.60	26.974	134.87	107.54	.21528	110.90	.22179	2.7623	.00552	3.025	0.
4.80	26.307	131.54	114.86	.22972	118.42	.23683	2.9242	.00585	3.002	0.

## RADIUM

PROTON ENERGY MEV	ENERGY LOSS HEV/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PATH LENGTH STRAGGLING CH	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	25.678	128.39	.12611	.02522	.00309	2.981
5.30	24.250	121.25	.14616	.02923	.00351	2.931
6.00	22.997	114.98	.16251	.03347	.00394	2.885
6.50	21.888	109.44	.18425	.03793	.00439	2.844
7.00	20.930	104.50	.21302	.04260	.00486	2.805
7.50	20.012	100.06	.23748	.04750	.00533	2.770
8.00	19.210	96.050	.26298	.05260	.00583	2.737
8.50	18.479	92.396	.28951	.05790	.00633	2.708
9.00	17.812	89.060	.31709	.06342	.00685	2.678
9.50	17.189	85.946	.34558	.06914	.00739	2.651
10.00	16.634	83.170	.37526	.07505	.00795	2.626
11.00	15.639	78.197	.43730	.08748	.00910	2.581
12.00	14.779	73.894	.50312	.10062	.01031	2.540
13.00	14.023	70.114	.57260	.11432	.01157	2.503
14.00	13.353	66.763	.64571	.12914	.01288	2.470
15.00	12.751	63.754	.72239	.14448	.01424	2.440
16.00	12.217	61.084	.80254	.16031	.01565	2.413
17.00	11.732	58.662	.88608	.17722	.01709	2.387
18.00	11.291	56.455	.97297	.19459	.01858	2.363
19.00	10.886	54.430	1.06332	.21264	.02011	2.342
20.00	10.564	52.618	1.1567	.23134	.02167	2.321
22.00	9.8940	49.470	1.3523	.27045	.02489	2.284
24.00	9.3164	46.582	1.5607	.31215	.02828	2.251
26.00	8.8121	44.060	1.7815	.35630	.03182	2.221
28.00	8.3690	41.845	2.0145	.40289	.03551	2.196
30.00	7.9756	39.878	2.2592	.45184	.03935	2.172
32.00	7.6236	38.118	2.5101	.50326	.04333	2.150
34.00	7.3065	36.532	2.7841	.55683	.04744	2.129
36.00	7.0192	35.096	3.0832	.61264	.05169	2.111
38.00	6.7552	33.776	3.3542	.67085	.05608	2.094
40.00	6.5174	32.587	3.6553	.73106	.06059	2.079
45.00	6.0007	30.004	4.4559	.89116	.07241	2.045
50.00	5.5886	27.943	5.3203	1.0641	.08488	2.016
55.00	5.2272	26.136	6.2462	1.2492	.09807	1.991
60.00	4.9177	24.509	7.2326	1.4445	.11200	1.969
65.00	4.6502	23.251	8.2781	1.6556	.12664	1.950
70.00	4.4160	22.080	9.3812	1.8762	.14124	1.933
75.00	4.2093	21.046	10.543	2.1086	.15780	1.918
80.00	4.0252	20.126	11.758	2.3515	.17443	1.904
90.00	3.7119	18.560	14.348	2.8625	.20929	1.881

## RADIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	PERCENT		
100.00	3.4548	16.823	3.3647	17.142	3.4285	.24635	.04927	1.862	.07967
110.00	3.2396	19.752	3.9503	20.123	4.0246	.28547	.05709	1.845	.09296
120.00	3.0567	22.676	4.5751	23.302	4.6605	.32654	.06531	1.831	.10676
130.00	2.9004	26.178	5.2356	26.663	5.3326	.36942	.07388	1.819	.12100
140.00	2.7646	29.647	5.9295	30.193	6.0387	.41399	.08280	1.809	.13560
150.00	2.6453	33.284	6.6569	33.894	6.7789	.46017	.09203	1.800	.15051
160.00	2.5398	37.065	7.4130	37.741	7.5481	.50786	.10157	1.791	.16568
170.00	2.4457	41.010	8.2020	41.795	8.3509	.55698	.11140	1.784	.18108
180.00	2.3614	45.101	9.0201	45.917	9.1833	.60748	.12150	1.777	.19667
190.00	2.2853	49.330	9.8660	50.220	10.044	.65928	.13186	1.771	.21240
200.00	2.2164	53.697	10.739	54.662	10.932	.71232	.14246	1.766	.22823
210.00	2.1537	58.197	11.639	59.241	11.846	.76653	.15331	1.761	.24414
220.00	2.0963	62.821	12.564	63.944	12.789	.82186	.16437	1.757	.26012
230.00	2.0437	67.570	13.514	68.775	13.755	.87826	.17565	1.753	.27614
240.00	1.9975	72.438	14.488	73.728	14.746	.93559	.18712	1.749	.29215
250.00	1.9526	77.413	15.483	78.788	15.758	.99381	.19876	1.746	.30813
260.00	1.9110	82.501	16.501	83.970	16.794	1.0530	.21060	1.742	.32406
270.00	1.8725	87.698	17.540	89.250	17.850	1.1130	.22261	1.739	.33992
280.00	1.8366	92.921	18.596	94.624	18.925	1.1740	.23479	1.736	.35569
290.00	1.8031	98.386	19.677	100.12	20.024	1.2357	.24714	1.734	.37134
300.00	1.7718	103.59	20.778	105.72	21.144	1.2983	.25965	1.731	.38686
310.00	1.7414	109.49	21.898	111.42	22.283	1.3616	.27232	1.729	.40224
320.00	1.7139	115.21	23.042	117.23	23.447	1.4257	.28514	1.726	.41751
330.00	1.6880	120.99	24.198	123.11	24.623	1.4905	.29810	1.724	.43262
340.00	1.6637	126.86	25.372	129.08	25.816	1.5560	.31119	1.722	.44759
350.00	1.6408	132.76	26.551	135.08	27.016	1.6220	.32441	1.721	.46239
360.00	1.6191	138.70	27.757	141.21	28.243	1.6887	.33775	1.720	.47694
370.00	1.5987	144.67	28.993	147.50	29.500	1.7560	.35120	1.718	.49132
380.00	1.5793	151.16	30.231	153.79	30.759	1.8238	.36476	1.716	.50549
390.00	1.5609	157.42	31.484	160.16	32.033	1.8922	.37843	1.714	.51943
400.00	1.5435	163.75	32.751	166.61	33.322	1.9610	.39220	1.713	.53314
420.00	1.5269	170.16	34.032	173.12	34.629	2.0304	.40607	1.711	.54662
430.00	1.5112	176.63	35.327	179.71	35.941	2.1032	.42003	1.710	.55988
440.00	1.4962	183.17	36.635	186.36	37.271	2.1704	.43409	1.708	.57291
450.00	1.4819	189.78	37.955	193.07	38.615	2.2412	.44823	1.707	.58571
460.00	1.4683	196.44	39.289	199.85	39.971	2.3123	.46246	1.705	.59826
470.00	1.4553	203.17	40.634	206.69	41.339	2.3858	.47676	1.704	.61057
480.00	1.4429	209.96	41.991	213.60	42.719	2.4557	.49114	1.703	.62262
490.00	1.4310	216.80	43.360	220.55	44.111	2.5280	.50560	1.703	.63443
	1.4197	223.70	44.740	227.57	45.514	2.6006	.52013	1.701	.64599

# RADIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.4088	230.65	234.64	2.6736	1.139	.65729
510.00	1.3984	237.70	241.81	2.7470	1.136	.66833
520.00	1.3885	244.79	249.02	2.8206	1.133	.67912
530.00	1.3789	251.90	256.25	2.8945	1.130	.68945
540.00	1.3697	259.06	263.53	2.9688	1.127	.69992
550.00	1.3609	266.27	270.86	3.0433	1.124	.70995
560.00	1.3525	273.52	278.23	3.1181	1.121	.71971
570.00	1.3443	280.82	285.65	3.1932	1.118	.72923
580.00	1.3365	288.16	293.12	3.2685	1.115	.73849
590.00	1.3290	295.54	300.62	3.3441	1.112	.74751
600.00	1.3217	302.96	308.17	3.4200	1.110	.75328
620.00	1.3080	317.93	323.39	3.5723	1.105	.77310
640.00	1.2953	333.04	338.76	3.7255	1.100	.78898
660.00	1.2835	348.31	354.28	3.8795	1.095	.80394
680.00	1.2725	363.71	369.94	4.0343	1.091	.81802
700.00	1.2622	379.24	385.73	4.1898	1.086	.83124
720.00	1.2526	394.89	401.64	4.3459	1.082	.84364
740.00	1.2436	410.67	417.68	4.5027	1.078	.85527
760.00	1.2352	426.55	433.83	4.6601	1.074	.86614
780.00	1.2274	442.54	450.08	4.8180	1.070	.87650
800.00	1.2200	458.63	466.43	4.9764	1.067	.88578
820.00	1.2131	474.81	482.68	5.1353	1.063	.89462
840.00	1.2066	491.09	499.43	5.2947	1.060	.90285
860.00	1.2005	507.46	516.07	5.4545	1.057	.91050
880.00	1.1947	523.91	532.79	5.6146	1.054	.91761
900.00	1.1893	540.44	549.59	5.7754	1.051	.92422
920.00	1.1843	557.05	566.47	5.9354	1.048	.93034
940.00	1.1795	573.72	583.41	6.0977	1.045	.93601
960.00	1.1750	590.47	600.42	6.2594	1.042	.94125
1000.00	1.1667	624.80	635.31	6.5837	1.036	.95052

THE ELECTRON DENSITY OF RADIUM IS 2.345E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.904 SEV, AND THE MINIMUM ENERGY LOSS IS 1.1067 MEV/GM/CM2

## SELENIUM

ATOMIC  
NUMBER  
34  
ELEMENT  
SE  
ATOMIC  
WEIGHT  
78.960  
ADJUSTED  
IONIZATION  
POTENTIAL  
338.7

DENSITY = 4.2850 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GH/CM2	HEV/CH	MG/CM2	MM	MG/CM2	MM	MG/CM2	MM			
.10	272.25	1309.5	.58863	.00122	.50331	.00126	.02327	.00006	4.506	2.755	0.
.15	246.57	1186.0	.78039	.00142	.79821	.00166	.03207	.00007	4.018	2.233	0.
.20	224.72	1080.9	.99023	.00206	1.0106	.00216	.03770	.00008	3.731	2.012	0.
.30	191.02	918.81	1.4672	.00365	1.4944	.00311	.05072	.00011	3.394	1.824	0.
.40	168.14	808.75	2.0183	.00420	2.0540	.00427	.06548	.00014	3.188	1.738	0.
.50	153.11	736.46	2.6334	.00547	2.6785	.00557	.08121	.00017	3.032	1.681	0.
.60	142.95	687.59	3.3003	.00686	3.3552	.00698	.09720	.00020	2.897	1.636	0.
.70	134.66	647.71	4.0108	.00834	4.0759	.00847	.11326	.00024	2.779	1.597	0.
.80	125.27	602.55	4.7691	.00992	4.8448	.01007	.13051	.00027	2.694	1.561	0.
.90	116.33	559.53	5.5865	.01161	5.6731	.01179	.14972	.00031	2.639	1.528	0.
1.00	107.37	516.47	6.4692	.01345	6.5675	.01365	.17114	.00036	2.606	1.497	0.
1.20	97.494	463.94	8.4029	.01747	8.1259	.01773	.21783	.00045	2.556	1.443	0.
1.40	89.731	431.61	10.517	.02166	10.466	.02186	.26584	.00055	2.502	1.399	0.
1.60	83.237	400.37	12.807	.02662	12.983	.02699	.31795	.00066	2.449	1.361	0.
1.80	77.728	373.87	15.266	.03174	15.471	.03217	.37128	.00077	2.400	1.328	0.
2.00	73.002	351.14	17.893	.03720	18.128	.03769	.42682	.00089	2.354	1.298	0.
2.20	68.906	331.44	20.682	.04300	20.949	.04355	.48453	.00101	2.313	1.271	0.
2.40	65.320	314.19	23.633	.04913	23.931	.04974	.54435	.00113	2.273	1.246	0.
2.60	62.144	293.91	26.740	.05559	27.072	.05625	.60623	.00126	2.239	1.226	0.
2.80	59.303	285.25	30.001	.06237	30.367	.06313	.67016	.00139	2.207	1.206	0.
3.00	56.747	272.96	33.414	.06947	33.916	.07030	.73611	.00153	2.177	1.188	0.
3.20	54.470	262.00	36.976	.07687	37.415	.07778	.80400	.00167	2.149	1.171	0.
3.40	52.367	251.88	40.684	.08458	41.160	.08557	.87360	.00182	2.123	1.156	0.
3.60	50.486	242.84	44.537	.09259	45.052	.09366	.94540	.00197	2.098	1.142	0.
3.80	48.756	234.51	48.531	.10090	49.085	.10205	1.0187	.00212	2.075	1.128	0.
4.00	47.156	226.82	52.659	.10948	53.254	.11071	1.0938	.00227	2.054	1.116	0.
4.20	45.673	219.69	56.931	.11836	57.566	.11958	1.1706	.00243	2.033	1.104	0.
4.40	44.291	213.04	61.337	.12752	62.015	.12891	1.2491	.00260	2.014	1.093	0.
4.60	43.003	206.85	65.875	.13695	66.596	.13845	1.3293	.00276	1.996	1.083	.00001
4.80	41.809	201.10	70.549	.14667	71.314	.14826	1.4112	.00293	1.979	1.073	.00001

## SELENIUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CH	GM/CM2	CH		
3.00	40.689	195.71	.07535	.01567	.07616	.01583	.00149	.00031	1.064	.00001
5.50	38.167	183.58	.08793	.01828	.08866	.01847	.00171	.00036	1.043	.00002
6.00	35.976	173.04	.10131	.02106	.10236	.02128	.00194	.00040	1.024	.00003
6.50	34.051	163.78	.11548	.02401	.11665	.02425	.00217	.00045	1.007	.00005
7.00	32.344	155.58	.13042	.02711	.13172	.02739	.00242	.00050	.9922	.00707
7.50	30.820	148.24	.14612	.03038	.14757	.03068	.00268	.00056	.9785	.00009
8.00	29.449	141.65	.16258	.03380	.16417	.03413	.00295	.00061	.9661	.00013
8.50	28.208	135.68	.17979	.03738	.18152	.03774	.00323	.00067	.9547	.00017
9.00	27.081	130.28	.19773	.04111	.19962	.04150	.00353	.00073	.9442	.00021
9.50	26.051	125.31	.21640	.04499	.21844	.04541	.00383	.00080	.9345	.00026
10.00	25.107	120.77	.23579	.04902	.23800	.04948	.00414	.00086	.9256	.00032
11.00	23.435	112.72	.27671	.05753	.27925	.05806	.00479	.00100	.9094	.00046
12.00	21.996	105.80	.32043	.06662	.32332	.06722	.00547	.00114	.8953	.00062
13.00	20.739	99.759	.36690	.07626	.37017	.07696	.00619	.00129	.8828	.00081
14.00	19.634	94.459	.41609	.08650	.41975	.08727	.00695	.00144	.8717	.00103
15.00	18.659	89.752	.46795	.09729	.47201	.09813	.00774	.00161	.8616	.00127
16.00	17.782	85.532	.52244	.10862	.52694	.10955	.00856	.00178	.8526	.00262
17.00	17.004	81.790	.57953	.12048	.58447	.12151	.00941	.00196	.8444	.00481
18.00	16.300	78.461	.63911	.13287	.64430	.13399	.01030	.00214	.8368	.00703
19.00	15.658	75.314	.70127	.14579	.70714	.14701	.01121	.00233	.8299	.00927
20.00	15.071	72.492	.76591	.15923	.77227	.16056	.01215	.00253	.8235	.01153
22.00	14.035	67.507	.90250	.18763	.90989	.18917	.01413	.00294	.8121	.01611
24.00	13.148	63.241	1.0487	.21803	1.0572	.21979	.01622	.00337	.8021	.02076
26.00	12.379	59.544	1.2044	.25040	1.2141	.25240	.01842	.00383	.7934	.02387
28.00	11.707	56.308	1.3694	.28471	1.3803	.28696	.02073	.00431	.7853	.02537
30.00	11.112	53.451	1.5436	.32092	1.5557	.32343	.02315	.00481	.7787	.02693
32.00	10.584	50.907	1.7268	.35899	1.7402	.36179	.02567	.00534	.7724	.02855
34.00	10.110	48.627	1.9188	.39891	1.9336	.40200	.02829	.00588	.7667	.03023
36.00	9.6821	46.571	2.1196	.44066	2.1338	.44404	.03101	.00645	.7615	.03197
38.00	9.2997	44.731	2.3283	.48416	2.3466	.48785	.03383	.00703	.7568	.03375
40.00	8.9461	43.031	2.5466	.52943	2.5659	.53344	.03674	.00764	.7524	.03553
45.00	8.1853	39.371	3.1275	.65021	3.1509	.65506	.04444	.00924	.7429	.04038
50.00	7.5616	36.371	3.7592	.78155	3.7871	.78733	.05270	.01096	.7349	.04543
55.00	7.0402	33.864	4.4404	.92315	4.4729	.92992	.06149	.01278	.7281	.05073
60.00	6.5976	31.734	5.1694	1.0747	5.2071	1.0825	.07081	.01472	.7223	.05630
65.00	6.2163	29.901	5.9452	1.2360	5.9882	1.2449	.08064	.01676	.7171	.06210
70.00	5.8851	28.307	6.7666	1.4068	6.8152	1.4169	.09094	.01891	.7126	.06813
75.00	5.5941	26.908	7.6327	1.5848	7.6871	1.5982	.10171	.02115	.7087	.07436
80.00	5.3363	25.568	8.5419	1.7759	8.6025	1.7885	.11293	.02348	.7051	.08076
90.00	4.8998	23.568	10.467	2.1802	10.961	2.1955	.13667	.02841	.6990	.09401



## SELENIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH CM		CM/CM <sup>2</sup>	PATH LENGTH STRAGGLING CM		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
			GM/CM <sup>2</sup>	CM		CM	PERCENT		
100.00	4.5438	21.856	12.682	2.6366	16205	0.3369	1.278	.6339	.10774
110.00	4.2478	20.432	14.968	3.1102	18897	0.3929	1.263	.6897	.12194
120.00	3.9977	19.229	17.388	3.6150	21735	0.4519	1.250	.6861	.13652
130.00	3.7831	18.197	19.961	4.1499	24712	0.5138	1.235	.6829	.15168
140.00	3.5975	17.304	22.673	4.7138	27819	0.5784	1.227	.6802	.16704
150.00	3.4352	16.523	25.519	5.3054	31050	0.6455	1.217	.6778	.18262
160.00	3.2919	15.834	28.494	5.9239	34396	0.7151	1.207	.6757	.19845
170.00	3.1646	15.222	31.593	6.5682	37858	0.7871	1.198	.6738	.21454
180.00	3.0508	14.674	34.811	7.2373	41424	0.8612	1.190	.6721	.23084
190.00	2.9482	14.181	38.146	7.9306	45091	0.9374	1.182	.6706	.24729
200.00	2.8555	13.738	41.593	8.6473	48855	1.0157	1.175	.6692	.26385
210.00	2.7713	13.330	45.149	9.3865	52710	1.0958	1.167	.6679	.28047
220.00	2.6943	12.960	48.809	10.147	56654	1.1778	1.161	.6667	.29713
230.00	2.6239	12.621	52.571	10.929	60681	1.2616	1.154	.6656	.31377
240.00	2.5591	12.309	56.430	11.732	64789	1.3470	1.148	.6646	.33039
250.00	2.4993	12.022	60.385	12.554	68973	1.4339	1.142	.6636	.34690
260.00	2.4440	11.756	64.432	13.395	73231	1.5225	1.137	.6628	.36335
270.00	2.3927	11.509	68.567	14.255	77559	1.6124	1.131	.6619	.37973
280.00	2.3450	11.279	72.789	15.133	81954	1.7038	1.126	.6612	.39600
290.00	2.3005	11.066	77.095	16.028	86414	1.7963	1.121	.6604	.41216
300.00	2.2590	10.866	81.482	16.940	90935	1.8905	1.116	.6597	.42816
310.00	2.2201	10.679	85.947	17.868	95516	1.9858	1.111	.6591	.44402
320.00	2.1836	10.503	90.489	18.813	1.0015	2.0822	1.107	.6584	.45971
330.00	2.1493	10.338	95.105	19.772	1.0485	2.1798	1.102	.6578	.47523
340.00	2.1171	10.183	99.793	20.747	1.0959	2.2784	1.098	.6572	.49056
350.00	2.0867	10.037	104.55	21.736	1.1439	2.3781	1.094	.6567	.50568
360.00	2.0580	9.890	109.38	22.739	1.1923	2.4788	1.090	.6561	.52058
370.00	2.0309	9.7685	114.27	23.756	1.2412	2.5805	1.086	.6556	.53522
380.00	2.0052	9.6430	119.22	24.787	1.2906	2.6831	1.082	.6551	.54961
390.00	1.9809	9.5279	124.24	25.830	1.3403	2.7866	1.079	.6546	.56374
400.00	1.9578	9.4169	129.32	26.886	1.3905	2.8909	1.075	.6541	.57759
410.00	1.9358	9.3114	134.46	27.953	1.4411	2.9961	1.072	.6536	.59116
420.00	1.9150	9.2110	139.65	29.033	1.4921	3.1021	1.068	.6532	.60446
430.00	1.8951	9.1156	144.90	30.125	1.5435	3.2089	1.065	.6527	.61746
440.00	1.8762	9.0246	150.20	31.227	1.5952	3.3164	1.062	.6523	.63018
450.00	1.8582	8.9378	155.56	32.341	1.6472	3.4246	1.059	.6518	.64261
460.00	1.8410	8.8550	160.97	33.465	1.6996	3.5335	1.056	.6514	.65474
470.00	1.8245	8.7759	166.42	34.599	1.7523	3.6431	1.053	.6510	.66658
480.00	1.8088	8.7003	171.93	35.744	1.8054	3.7533	1.050	.6506	.67812
490.00	1.7938	8.6280	177.48	36.898	1.8587	3.8642	1.047	.6501	.68936

# SELENIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GH/CM2	PROTON RANGE GH/CM2	PROTON PATH LENGTH GH/CM2	PATH LENGTH STRAGGLING GH/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.7794	181.89	183.08	1.9123	.6497	.70031
510.00	1.7656	187.49	188.72	1.9662	.6493	.71097
520.00	1.7523	193.14	194.40	2.0203	.6489	.72133
530.00	1.7397	198.83	200.13	2.0748	.6485	.73140
540.00	1.7275	204.56	205.90	2.1294	.6481	.74119
550.00	1.7158	210.34	211.71	2.1843	.6477	.75069
560.00	1.7045	216.15	217.55	2.2395	.6473	.75992
570.00	1.6937	221.99	223.44	2.2949	.6469	.76886
580.00	1.6833	227.88	229.36	2.3505	.6465	.77753
590.00	1.6733	233.80	235.32	2.4063	.6461	.78594
600.00	1.6637	239.76	241.31	2.4623	.6458	.79408
620.00	1.6455	251.77	253.40	2.5749	.6450	.80959
640.00	1.6285	263.91	265.62	2.6883	.6442	.82411
660.00	1.6127	276.17	277.96	2.8034	.6434	.83767
680.00	1.5980	288.56	290.42	2.9172	.6426	.85032
700.00	1.5843	301.05	302.99	3.0326	.6418	.86211
720.00	1.5714	313.64	315.67	3.1486	.6411	.87307
740.00	1.5594	326.34	328.44	3.2652	.6403	.88326
760.00	1.5481	339.13	341.32	3.3823	.6395	.89271
780.00	1.5376	352.02	354.28	3.4999	.6387	.90147
800.00	1.5276	364.99	367.33	3.6180	.6379	.90959
820.00	1.5183	378.04	380.46	3.7366	.6371	.91709
840.00	1.5095	391.17	393.68	3.8555	.6363	.92402
860.00	1.5012	404.38	406.97	3.9749	.6355	.93041
880.00	1.4934	417.66	420.33	4.0947	.6347	.93631
900.00	1.4861	431.01	433.76	4.2148	.6338	.94174
920.00	1.4792	444.44	447.27	4.3354	.6330	.94675
940.00	1.4726	457.92	460.84	4.4562	.6320	.95134
960.00	1.4664	471.49	474.48	4.5774	.6309	.95557
1000.00	1.4551	498.92	502.08	4.8207	.6279	.96298

THE ELECTRON DENSITY OF SELENIUM IS 2.594E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.064 BEV, AND THE MINIMUM ENERGY LOSS IS 1.3671 MEV/GH/CM2

# SILICON

ELEMENT Si  
ATOMIC NUMBER 14  
ATOMS/MOLECULE 1  
ATOMIC WEIGHT 28.086  
ADJUSTED IONIZATION POTENTIAL 170.0

DENSITY = 2.3300 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS GM/CM <sup>2</sup>	ENERGY LOSS MEV/CM	PROTON RANGE HG/CM <sup>2</sup>	PROTON RANGE MN	PROTON PATH LENGTH HG/CM <sup>2</sup>	PROTON PATH LENGTH MN	PROTON PATH LENGTH STRAGGLING HG/CM <sup>2</sup>	PROTON PATH LENGTH STRAGGLING MN	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	432.01	1006.6	.28403	.00122	.20803	.00124	.01119	.00005	1.387	0.
.15	382.61	891.48	.40657	.00174	.41094	.00176	.01483	.00006	1.063	0.
.20	350.19	815.95	.54234	.00233	.54750	.00235	.01863	.00008	.9426	0.
.30	303.29	706.67	.84784	.00364	.85507	.00367	.02635	.00011	.8457	0.
.40	270.91	631.21	1.1950	.00513	1.2046	.00517	.03431	.00015	.7972	0.
.50	245.55	572.14	1.5804	.00678	1.5925	.00683	.04256	.00018	.7622	0.
.60	223.98	521.87	2.0045	.00860	2.0193	.00867	.05128	.00022	.7334	0.
.70	206.41	480.94	2.4667	.01039	2.4843	.01066	.06050	.00026	.7088	0.
.80	191.79	446.87	2.9664	.01273	2.9869	.01282	.07024	.00030	.6872	0.
.90	184.06	428.86	3.4952	.01500	3.5187	.01510	.08017	.00034	.6683	0.
1.00	176.32	410.82	4.0476	.01737	4.0741	.01749	.09023	.00039	.6513	0.
1.20	157.68	367.40	5.2423	.02250	5.2751	.02254	.1201	.00048	.6215	0.
1.40	142.82	332.78	6.5707	.02820	6.6101	.02837	.13643	.00059	.5962	0.
1.60	131.14	305.57	8.0263	.03445	8.0727	.03465	.16301	.00070	.5747	0.
1.80	121.22	282.43	9.6124	.04125	9.6661	.04149	.19170	.00082	.5562	0.
2.00	112.90	263.05	11.311	.04854	11.372	.04881	.22218	.00095	.5404	.00001
2.20	105.76	246.43	13.135	.05637	13.204	.05667	.25443	.00109	.5263	.00001
2.40	99.598	232.06	15.078	.06471	15.156	.06505	.28837	.00124	.5141	.00002
2.60	94.156	219.38	17.137	.07355	17.223	.07392	.32395	.00139	.5033	.00002
2.80	89.340	208.16	19.308	.08287	19.404	.08328	.36115	.00153	.4936	.00003
3.00	85.060	198.19	21.593	.09267	21.698	.09312	.39992	.00172	.4851	.00004
3.20	81.237	189.26	23.989	.10296	24.104	.10345	.44019	.00189	.4771	.00005
3.40	77.759	181.20	26.495	.11371	26.620	.11425	.48193	.00207	.4701	.00006
3.60	74.628	173.88	29.110	.12495	29.246	.12552	.52510	.00225	.4634	.00007
3.80	71.761	167.28	31.837	.13664	31.983	.13727	.56969	.00245	.4574	.00008
4.00	69.132	161.08	34.669	.14877	34.820	.14944	.61566	.00264	.4520	.00010
4.20	66.710	155.43	37.509	.16137	37.768	.16209	.66299	.00285	.4469	.00011
4.40	64.472	150.22	40.635	.17441	40.818	.17518	.71168	.00305	.4421	.00013
4.60	62.397	145.38	43.777	.18788	43.969	.18871	.76170	.00327	.4377	.00015
4.80	60.466	140.89	47.026	.20183	47.231	.20271	.81303	.00349	.4337	.00017

## SILICON

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CH	GM/CM2	PERCENT		
5.00	58.665	0.5037	0.2162	0.5050	0.2171	0.0087	1.711	0.4298	0.0019
5.50	54.652	0.5917	0.2540	0.5942	0.2550	0.0100	1.688	0.4212	0.0023
6.00	51.211	0.6860	0.2944	0.6888	0.2956	0.0113	1.666	0.4138	0.0033
6.50	48.223	0.7866	0.3374	0.7895	0.3388	0.0130	1.647	0.4072	0.0041
7.00	45.603	0.8916	0.3831	0.8962	0.3846	0.0146	1.630	0.4015	0.0051
7.50	43.351	1.0101	0.4312	1.0086	0.4329	0.0163	1.613	0.3964	0.0062
8.00	41.275	1.1224	0.4817	1.1268	0.4836	0.0180	1.598	0.3917	0.0072
8.50	39.410	1.2459	0.5347	1.2503	0.5368	0.0198	1.584	0.3875	0.0081
9.00	37.724	1.3752	0.5902	1.3805	0.5925	0.0217	1.572	0.3837	0.0090
9.50	36.193	1.5102	0.6482	1.5160	0.6506	0.0236	1.560	0.3802	0.0098
10.00	34.794	1.6506	0.7084	1.6568	0.7111	0.0257	1.549	0.3770	0.0105
11.00	32.331	1.9480	0.8360	1.9552	0.8392	0.0299	1.528	0.3712	0.0129
12.00	30.227	2.2670	0.9730	2.2754	0.9766	0.0344	1.511	0.362	0.0165
13.00	28.407	2.6074	1.1190	2.6168	1.1231	0.0391	1.495	0.3619	0.0202
14.00	26.816	2.9686	1.2741	2.9793	1.2787	0.0441	1.480	0.3580	0.0240
15.00	25.412	3.3506	1.4380	3.3625	1.4431	0.0493	1.467	0.3546	0.0281
16.00	24.163	3.7529	1.6107	3.7662	1.6164	0.0548	1.453	0.3514	0.0322
17.00	23.044	4.1757	1.7921	4.1903	1.7984	0.0605	1.444	0.3486	0.0366
18.00	22.035	4.6181	1.9820	4.6341	1.9889	0.0665	1.434	0.3460	0.0411
19.00	21.120	5.0802	2.1803	5.0977	2.1879	0.0726	1.425	0.3437	0.0458
20.00	20.286	5.5620	2.3871	5.5811	2.3953	0.0790	1.416	0.3415	0.0506
22.00	18.823	6.5830	2.8253	6.6053	2.8349	0.0925	1.400	0.3376	0.0570
24.00	17.572	7.6800	3.2962	7.7058	3.3072	0.1068	1.386	0.3343	0.0646
26.00	16.501	8.8515	3.7989	8.8809	3.8116	0.1219	1.373	0.3313	0.0734
28.00	15.567	1.0096	4.3332	1.0130	4.3475	0.1379	1.362	0.3287	0.0834
30.00	14.745	1.1413	4.8982	1.1450	4.9143	0.1547	1.351	0.3263	0.0941
32.00	14.016	1.2800	5.4936	1.2842	5.5115	0.1723	1.342	0.3242	0.1056
34.00	13.365	1.4257	6.1191	1.4303	6.1398	0.1906	1.333	0.3223	0.1182
36.00	12.779	1.5784	6.7742	1.5835	6.7960	0.2097	1.324	0.3206	0.1319
38.00	12.249	1.7378	7.4583	1.7434	7.4822	0.2295	1.317	0.3189	0.1466
40.00	11.767	1.9039	8.1713	1.9100	8.1973	0.2501	1.309	0.3175	0.1623
45.00	10.733	2.3480	1.0077	2.3554	1.0109	0.3046	1.293	0.3142	0.1808
50.00	9.8996	2.8324	1.2156	2.8413	1.2194	0.3634	1.279	0.3115	0.2016
55.00	9.1867	3.3558	1.4403	3.3663	1.4447	0.4263	1.266	0.3092	0.2249
60.00	8.5919	3.9174	1.6813	3.9294	1.6865	0.4932	1.255	0.3072	0.2502
65.00	8.0815	4.5160	1.9382	4.5290	1.9441	0.5635	1.245	0.3054	0.2779
70.00	7.6385	5.1509	2.2107	5.1666	2.2174	0.6383	1.236	0.3039	0.3073
75.00	7.2503	5.8211	2.4983	5.8367	2.5059	0.7163	1.227	0.3025	0.3388
80.00	6.9071	6.5258	2.8008	6.5455	2.8092	0.7978	1.219	0.3012	0.3714
90.00	6.3274	8.9360	3.4489	8.9601	3.4593	0.9706	1.204	0.2991	0.4354

# SILICON

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GH/CH2	MEV/CH	GH/CH2	CM	GM/CH2	CH	CM	PERCENT		
100.00	5.8562	13.645	9.6737	4.1527	9.7046	4.1651	.11561	.04962	1.191	.15481
110.00	5.4655	12.735	11.440	4.9097	11.474	4.9243	.13535	.05809	1.180	.17045
120.00	5.1360	11.967	13.323	5.7180	13.362	5.7349	.15621	.06704	1.169	.18350
130.00	4.8544	11.311	15.321	6.5756	15.366	6.5949	.17814	.07646	1.159	.20286
140.00	4.6108	10.743	17.430	7.4806	17.481	7.5026	.20108	.08630	1.150	.21942
150.00	4.3981	10.247	19.645	8.4314	19.703	8.4560	.22498	.09656	1.142	.23608
160.00	4.2106	9.8107	21.963	9.4263	22.027	9.4537	.24979	.10720	1.134	.25289
170.00	4.0442	9.4230	24.380	10.464	24.451	10.494	.27546	.11823	1.127	.26987
180.00	3.8955	9.0764	26.893	11.542	26.971	11.576	.30197	.12960	1.120	.28697
190.00	3.7618	8.7649	29.499	12.661	29.584	12.697	.32926	.14131	1.113	.30413
200.00	3.6409	8.4833	32.194	13.817	32.287	13.857	.35731	.15335	1.107	.32129
210.00	3.5312	8.2276	35.976	15.011	35.077	15.054	.38607	.16569	1.101	.33845
220.00	3.4311	7.9944	39.841	16.241	37.950	16.288	.41552	.17833	1.095	.35564
230.00	3.3394	7.7808	43.788	17.505	40.905	17.556	.44562	.19125	1.089	.37280
240.00	3.2552	7.5846	47.813	18.804	43.938	18.858	.47635	.20444	1.084	.38991
250.00	3.1776	7.4037	51.914	20.135	47.048	20.192	.50769	.21789	1.079	.40691
260.00	3.1058	7.2365	56.086	21.497	50.232	21.559	.53959	.23159	1.074	.42379
270.00	3.0392	7.0814	60.333	22.890	53.487	22.956	.57205	.24552	1.070	.44054
280.00	2.9773	6.9372	64.653	24.313	56.812	24.383	.60504	.25967	1.065	.45712
290.00	2.9197	6.8028	69.033	25.765	60.204	25.838	.63854	.27405	1.061	.47351
300.00	2.8658	6.6773	73.480	27.245	63.661	27.322	.67252	.28864	1.056	.48969
310.00	2.8154	6.5599	78.092	28.732	67.182	28.833	.70697	.30342	1.052	.50565
320.00	2.7681	6.4498	82.764	30.285	70.764	30.371	.74187	.31840	1.048	.52139
330.00	2.7237	6.3463	87.496	31.844	74.406	31.934	.77721	.33356	1.045	.53690
340.00	2.6820	6.2490	92.227	33.427	78.107	33.522	.81295	.34891	1.041	.55214
350.00	2.6426	6.1573	97.032	35.035	81.863	35.134	.84910	.36442	1.037	.56712
360.00	2.6054	6.0707	101.843	36.666	85.674	36.770	.88563	.38010	1.034	.58184
370.00	2.5703	5.9889	106.687	38.320	89.539	38.429	.92253	.39594	1.030	.59628
380.00	2.5371	5.9114	111.592	39.997	93.455	40.109	.95979	.41193	1.027	.61045
390.00	2.5056	5.8380	116.548	41.694	97.421	41.812	.99739	.42807	1.024	.62433
400.00	2.4757	5.7683	121.55	43.413	101.44	43.535	1.0353	.44435	1.021	.63792
410.00	2.4473	5.7021	126.60	45.152	105.50	45.279	1.0736	.46076	1.018	.65118
420.00	2.4202	5.6391	131.73	46.911	109.61	47.042	1.1121	.47731	1.015	.66410
430.00	2.3945	5.5792	136.94	48.689	113.76	48.825	1.1510	.49399	1.012	.67668
440.00	2.3700	5.5230	142.20	50.485	117.96	50.627	1.1902	.51080	1.009	.68891
450.00	2.3466	5.4695	147.53	52.297	122.20	52.447	1.2296	.52772	1.006	.70079
460.00	2.3242	5.4185	152.94	54.133	126.48	54.285	1.2693	.54476	1.004	.71232
470.00	2.3029	5.3697	158.40	56.003	130.81	56.140	1.3092	.56191	1.001	.72352
480.00	2.2824	5.3231	163.91	57.890	135.17	58.012	1.3495	.57917	.9984	.73437
490.00	2.2629	5.2785	169.48	59.794	139.57	59.900	1.3899	.59653	.9959	.74489

# SILICON

PROTON ENERGY MEV	ENERGY LOSS MEV/CM GM/CM2	PROTON RANGE CM/CM2	PROTON LENGTH CM/CM2	PATH LENGTH CH	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.2442	143.60	144.01	61.805	.75507
510.00	2.2262	148.07	148.48	63.725	.76492
520.00	2.2090	152.56	152.99	65.661	.77445
530.00	2.1925	157.10	157.53	67.611	.78367
540.00	2.1766	161.66	162.11	69.576	.79257
550.00	2.1613	166.26	166.72	71.554	.80116
560.00	2.1467	170.89	171.36	73.547	.80945
570.00	2.1326	175.55	176.04	75.553	.81745
580.00	2.1190	180.24	180.74	77.572	.82516
590.00	2.1059	184.96	185.48	79.604	.83259
600.00	2.0933	189.72	190.24	81.648	.83974
620.00	2.0694	199.30	199.85	85.773	.85326
640.00	2.0471	208.99	209.57	89.943	.86577
660.00	2.0264	218.79	219.39	94.138	.87733
680.00	2.0070	228.68	229.31	98.415	.88799
700.00	1.9889	238.66	239.32	102.71	.89781
720.00	1.9719	248.74	249.42	107.05	.90684
740.00	1.9560	258.89	259.60	111.42	.91514
760.00	1.9410	269.13	269.87	115.82	.92275
780.00	1.9269	279.45	280.21	120.26	.92973
800.00	1.9137	289.84	290.63	124.73	.93613
820.00	1.9012	300.30	301.11	129.23	.94197
840.00	1.8894	310.82	311.67	133.76	.94732
860.00	1.8783	321.41	322.29	138.32	.95219
880.00	1.8678	332.07	332.97	142.90	.95664
900.00	1.8579	342.78	343.71	147.51	.96070
920.00	1.8485	353.56	354.51	152.15	.96440
940.00	1.8396	364.39	365.37	156.81	.96776
960.00	1.8312	375.28	376.29	161.50	.97082
1000.00	1.8156	397.32	398.38	170.98	.97613
1100.00	1.7913	429.84	430.91	180.46	.98144
1200.00	1.7681	462.94	464.01	190.94	.98675
1300.00	1.7459	496.64	497.71	201.42	.99206
1400.00	1.7247	530.94	532.01	211.90	.99737
1500.00	1.7045	565.84	566.91	222.38	.99999
1600.00	1.6853	601.34	602.41	232.86	.99999
1700.00	1.6671	637.44	638.51	243.34	.99999
1800.00	1.6499	674.14	675.21	253.82	.99999
1900.00	1.6337	711.44	712.51	264.30	.99999
2000.00	1.6185	749.34	750.41	274.78	.99999
2100.00	1.6043	787.84	788.91	285.26	.99999
2200.00	1.5911	826.94	828.01	295.74	.99999
2300.00	1.5789	866.64	867.71	306.22	.99999
2400.00	1.5677	906.94	908.01	316.70	.99999
2500.00	1.5575	947.84	948.91	327.18	.99999
2600.00	1.5483	989.34	990.41	337.66	.99999
2700.00	1.5391	1031.44	1032.51	348.14	.99999
2800.00	1.5309	1074.14	1075.21	358.62	.99999
2900.00	1.5237	1117.44	1118.51	369.10	.99999
3000.00	1.5175	1161.34	1162.41	379.58	.99999
3100.00	1.5123	1205.84	1206.91	390.06	.99999
3200.00	1.5081	1250.94	1252.01	400.54	.99999
3300.00	1.5049	1296.64	1297.71	411.02	.99999
3400.00	1.5027	1342.94	1344.01	421.50	.99999
3500.00	1.5015	1389.84	1390.91	431.98	.99999
3600.00	1.5013	1437.34	1438.41	442.46	.99999
3700.00	1.5021	1485.44	1486.51	452.94	.99999
3800.00	1.5039	1534.14	1535.21	463.42	.99999
3900.00	1.5067	1583.44	1584.51	473.90	.99999
4000.00	1.5105	1633.34	1634.41	484.38	.99999
4100.00	1.5153	1683.84	1684.91	494.86	.99999
4200.00	1.5211	1734.94	1736.01	505.34	.99999
4300.00	1.5279	1786.64	1787.71	515.82	.99999
4400.00	1.5357	1838.94	1840.01	526.30	.99999
4500.00	1.5445	1891.84	1892.91	536.78	.99999
4600.00	1.5543	1945.34	1946.41	547.26	.99999
4700.00	1.5651	1999.44	2000.51	557.74	.99999
4800.00	1.5769	2054.14	2055.21	568.22	.99999
4900.00	1.5897	2109.44	2110.51	578.70	.99999
5000.00	1.6035	2165.34	2166.41	589.18	.99999
5100.00	1.6183	2221.84	2222.91	599.66	.99999
5200.00	1.6341	2278.94	2280.01	610.14	.99999
5300.00	1.6509	2336.64	2337.71	620.62	.99999
5400.00	1.6687	2394.94	2396.01	631.10	.99999
5500.00	1.6875	2453.84	2454.91	641.58	.99999
5600.00	1.7073	2513.34	2514.41	652.06	.99999
5700.00	1.7281	2573.44	2574.51	662.54	.99999
5800.00	1.7499	2634.14	2635.21	673.02	.99999
5900.00	1.7727	2695.44	2696.51	683.50	.99999
6000.00	1.7965	2757.34	2758.41	693.98	.99999
6100.00	1.8213	2820.84	2821.91	704.46	.99999
6200.00	1.8471	2885.94	2887.01	714.94	.99999
6300.00	1.8739	2952.64	2953.71	725.42	.99999
6400.00	1.9017	3020.94	3022.01	735.90	.99999
6500.00	1.9305	3090.84	3091.91	746.38	.99999
6600.00	1.9603	3162.34	3163.41	756.86	.99999
6700.00	1.9911	3235.44	3236.51	767.34	.99999
6800.00	2.0229	3309.14	3310.21	777.82	.99999
6900.00	2.0557	3384.44	3385.51	788.30	.99999
7000.00	2.0895	3461.34	3462.41	798.78	.99999
7100.00	2.1243	3539.84	3540.91	809.26	.99999
7200.00	2.1601	3619.94	3621.01	819.74	.99999
7300.00	2.1969	3701.64	3702.71	830.22	.99999
7400.00	2.2347	3784.94	3786.01	840.70	.99999
7500.00	2.2735	3869.84	3870.91	851.18	.99999
7600.00	2.3133	3956.34	3957.41	861.66	.99999
7700.00	2.3541	4044.44	4045.51	872.14	.99999
7800.00	2.3959	4134.14	4135.21	882.62	.99999
7900.00	2.4387	4225.44	4226.51	893.10	.99999
8000.00	2.4825	4318.34	4319.41	903.58	.99999
8100.00	2.5273	4412.84	4413.91	914.06	.99999
8200.00	2.5731	4508.94	4510.01	924.54	.99999
8300.00	2.6199	4606.64	4607.71	935.02	.99999
8400.00	2.6677	4705.94	4707.01	945.50	.99999
8500.00	2.7165	4806.84	4807.91	955.98	.99999
8600.00	2.7663	4909.34	4910.41	966.46	.99999
8700.00	2.8171	5013.44	5014.51	976.94	.99999
8800.00	2.8689	5119.14	5120.21	987.42	.99999
8900.00	2.9217	5226.44	5227.51	997.90	.99999
9000.00	2.9755	5335.34	5336.41	1008.38	.99999
9100.00	3.0303	5445.84	5446.91	1018.86	.99999
9200.00	3.0861	5557.94	5559.01	1029.34	.99999
9300.00	3.1429	5671.64	5672.71	1039.82	.99999
9400.00	3.2007	5786.94	5788.01	1050.30	.99999
9500.00	3.2595	5903.84	5904.91	1060.78	.99999
9600.00	3.3193	6022.34	6023.41	1071.26	.99999
9700.00	3.3801	6142.44	6143.51	1081.74	.99999
9800.00	3.4419	6264.14	6265.21	1092.22	.99999
9900.00	3.5047	6387.44	6388.51	1102.70	.99999
10000.00	3.5685	6512.34	6513.41	1113.18	.99999

THE ELECTRON DENSITY OF SILICON IS 3.00SE 23 ELECTRONS PER GRAH

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.175 BEV, AND THE MINIMUM ENERGY LOSS IS 1.6758 MEV/GM/CM2

## SILVER

ADJUSTED  
IONIZATION  
POTENTIAL  
465.0

ATOMIC  
WEIGHT  
107.87

ATOMS/  
MOLECULE  
1

ELEMENT  
NUMBER  
47

AG

DENSITY = 10.500 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS GM/CM <sup>2</sup>	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH MM	PROTON PATH LENGTH MM	PATH LENGTH STRAGGLING MM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	252.50	.78282	.00075	.81154	.03840	3.540	0.
.15	225.93	.99058	.00094	1.0208	.04250	2.958	0.
.20	204.33	1.2199	.00116	1.2534	.04739	2.675	0.
.30	172.41	1.7446	.00166	1.7878	.05984	2.415	0.
.40	150.62	2.3545	.00224	2.4098	.07702	2.295	0.
.50	134.57	3.0438	.00290	3.1130	.09736	2.222	0.
.60	121.63	3.8107	.00363	3.8951	.12001	2.168	0.
.70	110.90	4.6559	.00443	4.7571	.14479	2.126	0.
.80	103.26	5.5750	.00531	5.6940	.17121	2.090	0.
.90	97.942	6.5496	.00624	6.6874	.19797	2.059	0.
1.00	92.620	7.5809	.00722	7.7380	.22515	2.031	0.
1.20	84.231	9.8066	.00934	10.005	.28147	1.981	0.
1.40	77.506	12.241	.01166	12.483	.34013	1.936	0.
1.60	72.232	14.873	.01417	15.161	.40088	1.896	0.
1.80	67.620	17.688	.01685	18.023	.46442	1.859	0.
2.00	63.693	20.689	.01970	21.074	.53203	1.826	0.
2.20	60.299	23.862	.02273	24.296	.60310	1.795	0.
2.40	57.326	27.213	.02592	27.702	.67720	1.767	0.
2.60	54.692	30.732	.02927	31.277	.75402	1.740	0.
2.80	52.337	34.415	.03278	35.016	.83337	1.716	0.
3.00	50.214	38.261	.03644	38.920	.91511	1.693	0.
3.20	48.287	42.260	.04025	42.979	.99912	1.672	0.
3.40	46.528	46.424	.04421	47.204	1.0853	1.652	0.
3.60	44.911	50.737	.04832	51.580	1.1737	1.633	0.
3.80	43.427	55.200	.05257	56.107	1.2642	1.616	0.
4.00	42.055	59.814	.05697	60.786	1.3567	1.599	0.
4.20	40.783	64.581	.06151	65.620	1.4511	1.584	0.
4.40	39.599	69.488	.06618	70.595	1.5475	1.569	0.
4.60	38.495	74.541	.07099	75.718	1.6459	1.555	0.
4.80	37.460	79.738	.07594	80.986	1.7461	1.541	0.

## SILVER

PRCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	HEV/ GM/CM2	MEV/CH	GH/CM2	CM	GH/CM2	CH	GH/CM2	PERCENT		
5.00	36.488	383.12	.08508	.00810	.08640	.00823	.00185	.00018	1.529	0.
5.50	34.291	360.06	.09903	.00243	.10054	.00958	.00231	.00020	1.499	0.
6.00	32.387	340.07	.11385	.01084	.11535	.01100	.00239	.00023	1.473	0.
6.50	30.715	322.51	.12951	.01233	.13141	.01252	.00267	.00025	1.450	.00001
7.00	29.255	307.18	.14598	.01390	.14810	.01410	.00297	.00028	1.428	.00002
7.50	27.946	293.43	.16326	.01555	.16559	.01577	.00327	.00031	1.409	.00003
8.00	26.766	281.04	.18132	.01727	.18388	.01751	.00359	.00034	1.391	.00004
8.50	25.694	269.78	.20017	.01906	.20296	.01933	.00391	.00037	1.375	.00006
9.00	24.715	259.51	.21978	.02093	.22280	.02122	.00425	.00040	1.359	.00008
9.50	23.821	250.12	.24014	.02287	.24341	.02318	.00459	.00044	1.345	.00011
10.00	22.994	241.43	.26126	.02489	.26478	.02522	.00494	.00047	1.332	.00014
11.00	21.540	226.17	.30568	.02911	.30973	.02950	.00568	.00054	1.308	.00022
12.00	20.278	212.92	.35301	.03362	.35761	.03406	.00644	.00061	1.287	.00033
13.00	19.178	201.37	.40316	.03840	.40834	.03889	.00725	.00069	1.268	.00046
14.00	18.205	191.15	.45610	.04344	.46188	.04399	.00809	.00077	1.251	.00062
15.00	17.337	182.04	.51179	.04874	.51819	.04935	.00898	.00085	1.236	.00080
16.00	16.557	173.85	.57019	.05430	.57724	.05498	.00989	.00094	1.222	.00101
17.00	15.853	166.46	.63126	.06012	.63899	.06086	.01085	.00103	1.209	.00124
18.00	15.213	159.74	.69455	.06619	.70338	.06699	.01183	.00113	1.197	.00154
19.00	14.630	153.61	.76129	.07250	.77043	.07337	.01286	.00122	1.184	.00229
20.00	14.095	148.00	.83024	.07907	.84012	.08001	.01391	.00132	1.176	.00329
22.00	13.149	138.06	.97571	.09292	.98715	.09401	.01611	.00153	1.158	.00728
24.00	12.336	129.53	1.1312	.10773	1.1443	.10898	.01844	.00176	1.143	.01133
26.00	11.632	122.14	1.2966	.12348	1.3114	.12489	.02089	.00199	1.129	.01711
28.00	11.014	115.65	1.4715	.14015	1.4882	.14173	.02346	.00223	1.116	.02355
30.00	10.466	109.89	1.6560	.15771	1.6745	.15948	.02614	.00249	1.105	.01705
32.00	9.9758	104.75	1.8498	.17617	1.8703	.17812	.02894	.00276	1.095	.01830
34.00	9.5413	100.16	2.0528	.19551	2.0754	.19765	.03184	.00303	1.086	.02022
36.00	9.1480	96.054	2.2648	.21570	2.2895	.21805	.03485	.00332	1.078	.02188
38.00	8.7912	92.307	2.4857	.23674	2.5126	.23930	.03796	.00361	1.070	.02359
40.00	8.4653	88.885	2.7153	.25860	2.7445	.26138	.04117	.00392	1.063	.02535
45.00	7.7615	81.496	3.3269	.35685	3.3621	.32020	.04962	.00473	1.048	.02994
50.00	7.1822	75.413	3.9507	.38007	4.0325	.38404	.05866	.00559	1.035	.03177
55.00	6.6965	70.313	4.7653	.44812	4.7539	.45276	.06827	.00650	1.024	.03585
60.00	6.2831	65.972	5.4693	.52089	5.5254	.52623	.07842	.00747	1.015	.04517
65.00	5.9266	62.229	6.2813	.59822	6.3451	.60430	.08910	.00849	1.006	.05073
70.00	5.6159	58.767	7.1402	.68002	7.2123	.68688	.10028	.00955	.992	.05650
75.00	5.3427	56.098	8.0448	.76617	8.1255	.77386	.11196	.01066	.987	.06247
80.00	5.1003	53.553	8.9940	.85657	9.0837	.86511	.12410	.01182	.980	.06860
90.00	4.6892	49.236	11.022	1.0497	11.131	1.0601	.14975	.01425	.977	.08132



## SILVER

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH GM/CM <sup>2</sup>	PROTON PATH LENGTH STRAGGLING GM/CM <sup>2</sup>	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	4.3534	13.217	13.346	1.7712	.9691	.09453
120.00	4.0737	15.572	15.723	.20609	.9623	.10822
140.00	3.8395	16.078	16.253	.23654	.9565	.12441
160.00	3.6361	20.731	20.930	.26843	.9515	.13701
180.00	3.4599	23.527	23.752	.30168	.9471	.15195
200.00	3.3056	26.457	26.709	.33623	.9433	.16716
220.00	3.1694	29.519	29.789	.37200	.9400	.18264
240.00	3.0483	32.709	33.018	.40894	.9369	.19838
260.00	2.9399	36.020	36.360	.44692	.9342	.21434
280.00	2.8422	39.449	39.820	.48608	.9317	.23045
300.00	2.7533	42.991	43.394	.52619	.9295	.24669
320.00	2.6730	46.646	47.082	.56727	.9275	.26297
340.00	2.5997	50.405	50.876	.60926	.9256	.27922
360.00	2.5325	54.268	54.774	.65211	.9239	.29540
380.00	2.4706	58.230	58.772	.69580	.9224	.31148
400.00	2.4136	62.289	62.868	.74028	.9209	.32743
420.00	2.3609	66.441	67.057	.78552	.9196	.34333
440.00	2.3110	70.683	71.339	.83148	.9183	.35925
460.00	2.2654	75.014	75.709	.87814	.9171	.37516
480.00	2.2239	79.429	80.163	.92546	.9160	.39104
500.00	2.1842	83.926	84.701	.97342	.9149	.40687
520.00	2.1471	88.502	89.318	1.0220	.9140	.42260
540.00	2.1122	93.156	94.014	1.0711	.9130	.43818
560.00	2.0795	97.885	98.786	1.1209	.9121	.45362
580.00	2.0487	102.69	103.63	1.1711	.9113	.46888
600.00	2.0196	107.55	108.55	1.2219	.9105	.48395
620.00	1.9922	112.50	113.53	1.2732	.9097	.49881
640.00	1.9662	117.48	118.56	1.3243	.9090	.51344
660.00	1.9417	122.55	123.67	1.3771	.9082	.52783
680.00	1.9184	127.68	128.85	1.4298	.9075	.54197
700.00	1.8964	132.88	134.02	1.4828	.9068	.55586
720.00	1.8754	138.13	139.40	1.5363	.9062	.56949
740.00	1.8554	143.44	144.76	1.5902	.9055	.58286
760.00	1.8365	148.81	150.17	1.6444	.9049	.59595
780.00	1.8184	154.21	155.64	1.6991	.9043	.60884
800.00	1.8011	159.71	161.17	1.7540	.9037	.62142
820.00	1.7847	165.24	166.74	1.8094	.9031	.63374
840.00	1.7690	170.82	172.37	1.8650	.9025	.64578
860.00	1.7539	176.44	178.05	1.9210	.9019	.65754
880.00	1.7395	182.11	183.77	1.9772	.9013	.66903
900.00	1.7258	187.83	189.51	2.0345	.9007	.68033
920.00	1.7126	193.60	195.29	2.0928	.9001	.69153
940.00	1.6998	199.42	201.11	2.1520	.8995	.70263
960.00	1.6874	205.29	206.97	2.2121	.8989	.71363
980.00	1.6754	211.21	212.87	2.2732	.8983	.72453
1000.00	1.6637	217.18	218.81	2.3353	.8977	.73533

# SILVER

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	CH	CH	PATH LENGTH STRAGGLING GM/CM2	CH	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.7258	18.121	187.83	17.889	169.54	18.051	2.0338	1.073	.9008	.68023
510.00	1.7126	17.982	193.60	18.438	195.36	18.605	2.0006	1.070	.9002	.69116
520.00	1.7000	17.849	199.41	18.991	201.22	19.163	2.1477	1.067	.8997	.70182
530.00	1.6878	17.722	205.26	19.548	207.12	19.726	2.2051	1.065	.8992	.71219
540.00	1.6762	17.600	211.15	20.109	213.06	20.292	2.2627	1.062	.8986	.72229
550.00	1.6650	17.483	217.08	20.674	219.05	20.862	2.3206	1.059	.8981	.73212
560.00	1.6543	17.370	223.05	21.243	225.07	21.435	2.3787	1.057	.8976	.74168
570.00	1.6439	17.261	229.06	21.815	231.13	22.013	2.4371	1.054	.8971	.75097
580.00	1.6340	17.157	235.11	22.391	237.23	22.594	2.4956	1.052	.8966	.76000
590.00	1.6244	17.057	241.19	22.970	243.37	23.178	2.5544	1.050	.8960	.76876
600.00	1.6152	16.960	247.31	23.553	249.54	23.736	2.6134	1.047	.8955	.77726
620.00	1.5978	16.777	259.65	24.728	261.99	24.951	2.7320	1.043	.8945	.79352
640.00	1.5817	16.607	272.11	25.916	274.57	26.149	2.8514	1.038	.8935	.80878
660.00	1.5666	16.449	284.71	27.115	287.27	27.359	2.9715	1.034	.8925	.82310
680.00	1.5526	16.302	297.42	28.325	300.09	28.580	3.0922	1.030	.8915	.83651
700.00	1.5394	16.164	310.24	29.547	313.03	29.812	3.2136	1.027	.8905	.84905
720.00	1.5272	16.036	323.17	30.778	326.07	31.034	3.3355	1.023	.8895	.86075
740.00	1.5157	15.915	336.26	32.026	339.29	32.313	3.4581	1.019	.8886	.87166
760.00	1.5050	15.802	349.40	33.277	352.53	33.575	3.5811	1.016	.8876	.88182
780.00	1.4949	15.697	362.63	34.536	365.87	34.845	3.7047	1.013	.8866	.89126
800.00	1.4855	15.597	375.93	35.803	379.29	36.123	3.8287	1.009	.8855	.90004
820.00	1.4766	15.504	389.32	37.079	392.80	37.409	3.9532	1.006	.8846	.90817
840.00	1.4682	15.416	402.79	38.361	406.39	38.703	4.0781	1.004	.8836	.91571
860.00	1.4604	15.334	416.34	39.651	420.05	40.004	4.2035	1.001	.8825	.92269
880.00	1.4530	15.256	429.96	40.948	433.78	41.312	4.3292	.9980	.8815	.92915
900.00	1.4460	15.183	443.44	42.252	447.58	42.627	4.4552	.9954	.8804	.93511
920.00	1.4394	15.114	457.40	43.562	461.46	43.948	4.5817	.9929	.8793	.94061
940.00	1.4332	15.049	471.25	44.881	475.42	45.279	4.7084	.9904	.8783	.94568
960.00	1.4274	14.988	485.21	46.211	489.50	46.619	4.8355	.9878	.8763	.95034
1000.00	1.4166	14.875	513.40	48.895	517.92	49.326	5.0905	.9829	.8737	.95854

THE ELECTRON DENSITY OF SILVER IS 2.525E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.012 BEV, AND THE MINIMUM ENERGY LOSS IS 1.3304 MEV/GM/CH2

# STRONTIUM

ELEMENT NUMBER 38  
 ATOMIC NUMBER 38  
 ATOMS/ MOLECULE 1  
 ATOMIC WEIGHT 87.620  
 ADJUSTED IONIZATION POTENTIAL 378.1

DENSITY = 2.6000 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS MEV/CM2	PROTON RANGE MG/CM2	PROTON PATH LENGTH MG/CM2	PATH LENGTH STRAGGLING MM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	278.91	.64868	.66877	.00012	3.003	0.
.15	243.88	.33908	.86033	.00013	2.471	0.
.20	217.16	1.2536	1.0775	.00015	2.222	0.
.30	180.31	1.5531	1.5849	.00021	2.006	0.
.40	157.05	2.1393	2.1810	.00028	1.912	0.
.50	141.48	2.8001	2.8531	.00035	1.856	0.
.60	130.11	3.5257	3.5908	.00043	1.814	0.
.70	120.76	4.3197	4.3887	.00050	1.779	0.
.80	113.69	5.1510	5.2426	.00059	1.747	0.
.90	109.78	6.0442	6.1488	.00067	1.718	0.
1.00	99.873	6.9979	7.1182	.00076	1.690	0.
1.20	91.065	9.0643	9.2175	.00095	1.641	0.
1.40	83.937	11.324	11.507	.00115	1.598	0.
1.60	78.069	13.763	13.981	.00137	1.560	0.
1.80	73.133	16.376	16.630	.00160	1.525	0.
2.00	68.887	19.159	19.449	.00183	1.494	0.
2.20	65.156	22.106	22.435	.00208	1.465	0.
2.40	61.904	25.218	25.586	.00233	1.439	0.
2.60	58.990	28.488	28.897	.00259	1.415	0.
2.80	56.452	31.912	32.363	.00286	1.393	0.
3.00	54.150	35.488	35.982	.00314	1.373	0.
3.20	52.054	39.213	39.751	.00342	1.354	0.
3.40	50.138	43.084	43.667	.00371	1.336	0.
3.60	48.380	47.101	47.731	.00401	1.319	0.
3.80	46.760	51.258	51.936	.00431	1.304	0.
4.00	45.260	55.557	56.282	.00462	1.289	0.
4.20	43.866	59.956	60.774	.00494	1.276	0.
4.40	42.566	64.573	65.399	.00526	1.263	0.
4.60	41.353	69.292	70.169	.00559	1.250	0.
4.80	40.225	74.144	75.074	.00593	1.239	0.

# STRONTIUM

PROCTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CH	GM/CM2	CM		
3.00	39.148	.07913	.03043	.08011	.03081	.00163	.00663	1.228	.00001
5.50	36.786	.09217	.03545	.09329	.03588	.00186	.00072	1.203	.00001
6.00	34.727	.10603	.04078	.10729	.04127	.00210	.00081	1.180	.00002
6.50	32.913	.12067	.04641	.12208	.04696	.00236	.00091	1.160	.00003
7.00	31.311	.13609	.05234	.13767	.05295	.00262	.00101	1.142	.00004
7.50	29.876	.15228	.05857	.15402	.05924	.00289	.00111	1.126	.00006
8.00	28.582	.16924	.06509	.17114	.06582	.00317	.00122	1.111	.00009
8.50	27.408	.18694	.07190	.18901	.07270	.00346	.00133	1.097	.00012
9.00	26.338	.20537	.07899	.20762	.07985	.00376	.00145	1.084	.00016
9.50	25.354	.22454	.08636	.22697	.08730	.00408	.00157	1.072	.00020
10.00	24.453	.24443	.09401	.24705	.09502	.00440	.00169	1.061	.00025
11.00	22.851	.28638	.11015	.28940	.11131	.00507	.00195	1.042	.00037
12.00	21.469	.33114	.12736	.33457	.12868	.00579	.00223	1.024	.00051
13.00	20.264	.37868	.14565	.38254	.14713	.00654	.00251	1.009	.00068
14.00	19.203	.42895	.16498	.43326	.16664	.00732	.00282	.9954	.00088
15.00	18.260	.48190	.18535	.48669	.18719	.00814	.00313	.9831	.00110
16.00	17.417	.53750	.20673	.54278	.20876	.00899	.00346	.9720	.00166
17.00	16.656	.59572	.22912	.60151	.23135	.00988	.00380	.9619	.00226
18.00	15.967	.65654	.25252	.66285	.25494	.01080	.00415	.9526	.00408
19.00	15.340	.71991	.27689	.72677	.27933	.01175	.00452	.9441	.00621
20.00	14.762	.78579	.30223	.79322	.30508	.01273	.00490	.9362	.00837
22.00	13.759	.92507	.35579	.93368	.35911	.01478	.00568	.9222	.01273
24.00	12.900	1.0740	.41309	1.0839	.41688	.01695	.00652	.9100	.01716
26.00	12.155	1.2325	.47405	1.2437	.47835	.01923	.00740	.8993	.02017
28.00	11.501	1.4004	.53860	1.4129	.54344	.02162	.00831	.8898	.02362
30.00	10.923	1.5774	.60671	1.5915	.61210	.02412	.00928	.8813	.02315
32.00	10.408	1.7635	.67827	1.7790	.68425	.02672	.01028	.8737	.02475
34.00	9.9462	1.9586	.75330	1.9757	.75989	.02943	.01132	.8668	.02640
36.00	9.5291	2.1625	.83171	2.1812	.83893	.03223	.01240	.8605	.02811
38.00	9.1506	2.3749	.91344	2.3954	.92132	.03514	.01352	.8548	.02986
40.00	8.8055	2.5961	.99849	2.6183	1.0070	.03815	.01467	.8494	.03167
45.00	8.0623	3.1855	1.2352	3.2124	1.2356	.04607	.01772	.8379	.03638
50.00	7.4522	3.8262	1.4716	3.8581	1.4839	.05457	.02099	.8282	.04133
55.00	6.9417	4.5165	1.7371	4.5538	1.7515	.06362	.02447	.8200	.04654
60.00	6.5080	5.2552	2.0212	5.2983	2.0378	.07319	.02815	.8130	.05200
65.00	6.1346	6.0409	2.3234	6.0900	2.3423	.08328	.03203	.8068	.05771
70.00	5.8127	6.8722	2.6432	6.9277	2.6645	.09383	.03609	.8014	.06362
75.00	5.5266	7.7479	2.9799	7.8101	3.0039	.10486	.04033	.7966	.06973
80.00	5.2731	8.6676	3.3338	8.7371	3.3604	.11634	.04475	.7923	.07601
90.00	4.8434	10.634	4.0899	10.716	4.1223	.14063	.05409	.7850	.08902

# STRONTIUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM			
100.00	4.4931	11.682	12.764	4.9091	12.864	4.9477	.16659	.06407	1.295	.7789	.10251
110.00	4.2017	10.924	15.050	5.7884	15.167	5.8335	.19410	.07466	1.280	.7738	.11647
120.00	3.9554	10.284	17.486	6.7254	17.622	6.7775	.22310	.08581	1.266	.7695	.13092
130.00	3.7443	9.7351	20.067	7.7100	20.222	7.7775	.25348	.09749	1.254	.7658	.14578
140.00	3.5613	9.2595	22.786	8.7640	22.961	8.8313	.28519	.10969	1.242	.7625	.16091
150.00	3.4008	8.8421	25.639	9.8613	25.836	9.9368	.31815	.12236	1.231	.7597	.17630
160.00	3.2596	8.4749	28.622	11.038	28.840	11.092	.35231	.13550	1.222	.7571	.19194
170.00	3.1340	8.1483	31.729	12.203	31.970	12.296	.38759	.14907	1.212	.7548	.20784
180.00	3.0217	7.8563	34.955	13.444	35.220	13.546	.42396	.16306	1.204	.7528	.22396
190.00	2.9206	7.5934	38.298	14.730	38.588	14.841	.46134	.17744	1.196	.7510	.24024
200.00	2.8291	7.3556	41.752	16.059	42.068	16.180	.49969	.19219	1.188	.7494	.25663
210.00	2.7459	7.1394	45.315	17.429	45.656	17.560	.53897	.20730	1.181	.7478	.27307
220.00	2.6700	6.9420	48.981	18.839	49.350	18.981	.57914	.22275	1.174	.7464	.28952
230.00	2.6005	6.7612	52.749	20.288	53.145	20.440	.62016	.23852	1.167	.7452	.30592
240.00	2.5365	6.5949	56.611	21.773	57.035	21.937	.66198	.25461	1.161	.7440	.32226
250.00	2.4775	6.4415	60.571	23.296	61.024	23.471	.70458	.27099	1.155	.7429	.33849
260.00	2.4229	6.2995	64.623	24.855	65.106	25.041	.74791	.28766	1.149	.7419	.35466
270.00	2.3722	6.1678	68.764	26.448	69.278	26.645	.79196	.30460	1.143	.7409	.37080
280.00	2.3251	6.0453	72.992	28.074	73.536	28.283	.83668	.32180	1.138	.7400	.38689
290.00	2.2812	5.9312	77.302	29.732	77.878	29.953	.88205	.33925	1.133	.7391	.40290
300.00	2.2402	5.8245	81.694	31.421	82.302	31.654	.92805	.35694	1.128	.7383	.41882
310.00	2.2018	5.7246	86.164	33.140	86.804	33.386	.97464	.37486	1.123	.7376	.43461
320.00	2.1657	5.6309	90.710	34.889	91.384	35.148	1.0218	.39300	1.118	.7368	.45026
330.00	2.1319	5.5429	95.331	36.666	96.038	36.938	1.0695	.41135	1.114	.7361	.46576
340.00	2.1000	5.4601	100.02	38.470	100.76	38.755	1.1178	.42991	1.109	.7355	.48108
350.00	2.0700	5.3820	104.78	40.302	105.56	40.600	1.1665	.44866	1.105	.7348	.49621
360.00	2.0416	5.3083	109.61	42.159	110.42	42.471	1.2158	.46760	1.101	.7342	.51113
370.00	2.0148	5.2386	114.51	44.042	115.35	44.367	1.2655	.48672	1.097	.7336	.52580
380.00	1.9895	5.1726	119.47	45.949	120.35	46.288	1.3156	.50601	1.093	.7330	.54021
390.00	1.9654	5.1101	124.49	47.890	125.41	48.233	1.3662	.52547	1.089	.7325	.55436
400.00	1.9426	5.0508	129.57	49.834	130.52	50.202	1.4172	.54509	1.086	.7319	.56824
410.00	1.9210	4.9945	134.71	51.811	135.70	52.192	1.4686	.56486	1.082	.7314	.58184
420.00	1.9003	4.9409	139.90	53.809	140.93	54.205	1.5204	.58478	1.079	.7309	.59518
430.00	1.8807	4.8899	145.16	55.829	146.22	56.240	1.5726	.60485	1.075	.7304	.60824
440.00	1.8620	4.8413	150.46	57.870	151.57	58.295	1.6251	.62505	1.072	.7299	.62103
450.00	1.8442	4.7950	155.82	59.930	156.96	60.371	1.6780	.64539	1.069	.7294	.63353
460.00	1.8272	4.7508	161.23	62.010	162.41	62.466	1.7312	.66585	1.066	.7289	.64574
470.00	1.8110	4.7085	166.69	64.110	167.91	64.580	1.7848	.68644	1.063	.7284	.65767
480.00	1.7954	4.6682	172.19	66.227	173.45	66.713	1.8386	.70715	1.060	.7280	.66931
490.00	1.7806	4.6295	177.74	68.363	179.05	68.864	1.8927	.72798	1.057	.7275	.68066

# STRONTIUM

REGION ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	MEV/GH	GM/CM2	CM	GM/CM2	CH	GM/CM2	PERCENT		
500.00	1.7664	4.5925	183.34	70.516	184.68	71.033	1.9472	.74891	1.054	.69172
510.00	1.7527	4.5571	188.98	72.686	190.37	73.218	2.0019	.76996	1.052	.70250
520.00	1.7397	4.5231	194.67	74.873	196.09	75.421	2.0569	.79111	1.049	.71298
530.00	1.7271	4.4905	200.40	77.076	201.86	77.640	2.1121	.81235	1.046	.72319
540.00	1.7151	4.4593	206.17	79.295	207.67	79.874	2.1676	.83370	1.044	.73311
550.00	1.7035	4.4292	211.98	81.529	213.52	82.124	2.2234	.85514	1.041	.74275
560.00	1.6924	4.4004	217.82	83.778	219.41	84.389	2.2793	.87667	1.039	.75211
570.00	1.6818	4.3726	223.71	86.041	225.34	86.669	2.3355	.89829	1.036	.76121
580.00	1.6715	4.3459	229.63	88.319	231.30	88.963	2.3920	.91999	1.034	.77003
590.00	1.6616	4.3202	235.59	90.610	237.30	91.270	2.4486	.94178	1.032	.77858
600.00	1.6521	4.2955	241.58	92.915	243.34	93.592	2.5055	.96364	1.030	.78688
620.00	1.6341	4.2487	253.67	97.554	255.51	98.273	2.6198	1.0076	1.029	.80270
640.00	1.6174	4.2052	265.88	102.26	267.81	103.00	2.7348	1.0519	1.021	.81753
660.00	1.6018	4.1646	278.22	107.01	280.24	107.78	2.8506	1.0964	1.017	.83141
680.00	1.5873	4.1269	290.67	111.80	292.78	112.61	2.9670	1.1412	1.013	.84438
700.00	1.5737	4.0916	303.24	116.63	305.43	117.47	3.0841	1.1862	1.010	.85648
720.00	1.5610	4.0586	315.91	121.50	318.20	122.38	3.2017	1.2314	1.006	.86775
740.00	1.5491	4.0277	328.68	126.42	331.06	127.33	3.3200	1.2769	1.003	.87824
760.00	1.5380	3.9988	341.55	131.37	344.01	132.31	3.4387	1.3226	.9996	.88799
780.00	1.5276	3.9717	354.51	136.35	357.06	137.33	3.5580	1.3684	.9965	.89704
800.00	1.5178	3.9462	367.55	141.37	370.20	142.38	3.6777	1.4145	.9934	.90543
820.00	1.5086	3.9223	380.66	146.42	383.42	147.47	3.7979	1.4607	.9905	.91320
840.00	1.4999	3.8997	393.39	151.49	396.71	152.58	3.9185	1.5071	.9877	.92038
860.00	1.4917	3.8785	407.19	156.61	410.11	157.73	4.0395	1.5537	.9850	.92702
880.00	1.4841	3.8586	420.55	161.75	423.56	162.91	4.1609	1.6004	.9824	.93316
900.00	1.4768	3.8398	433.97	166.91	437.07	168.11	4.2827	1.6472	.9799	.93881
920.00	1.4700	3.8220	447.47	172.10	450.66	173.33	4.4048	1.6942	.9774	.94482
940.00	1.4636	3.8053	461.03	177.32	464.31	178.58	4.5273	1.7413	.9751	.94882
960.00	1.4575	3.7894	474.66	182.56	478.04	183.86	4.6501	1.7885	.9727	.95323
1000.00	1.4463	3.7604	502.25	193.17	505.80	194.54	4.8966	1.8833	.9681	.96098

THE ELECTRON DENSITY OF STRONTIUM IS 2.613E      ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.046 BEV, AND THE MINIMUM ENERGY LOSS IS 1.3606 MEV/GM/CM2

## TANTALUM

ELEMENT TA  
ATOMIC NUMBER 73  
ATOMS/MOLECULE 1  
ADJUSTED IONIZATION POTENTIAL 720.0  
ATOMIC WEIGHT 180.95

DENSITY = 16.600 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS MEV/GM/CM <sup>2</sup>	PROTON RANGE MM	PROTON PATH LENGTH MM/GM/CM <sup>2</sup>	PROTON PATH LENGTH STRAGGLING MM/GM/CM <sup>2</sup>	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	122.46	1.1631	1.2240	.00074	.06170	4.977
.15	124.37	1.5632	1.6292	.00098	.07590	4.046
.20	122.62	1.9576	2.0340	.00123	.08974	3.759
.30	112.67	2.7779	2.8820	.00174	.11747	3.610
.40	99.944	3.6871	3.8237	.00230	.14.33	3.574
.50	88.954	4.7122	4.8858	.00294	.18194	3.554
.60	81.387	5.8492	6.0436	.00365	.21955	3.536
.70	76.110	7.0770	7.3349	.00442	.25847	3.510
.80	69.167	8.4028	8.7070	.00525	.29969	2.493
.90	69.555	9.7952	10.147	.00611	.34059	3.460
1.00	69.942	11.184	11.582	.00698	.37599	3.440
1.20	64.454	14.072	14.564	.00877	.44680	3.375
1.40	59.881	17.198	17.786	.01071	.52499	3.304
1.60	56.022	20.555	21.242	.01280	.60885	3.233
1.80	52.706	24.137	24.926	.01502	.69741	3.164
2.00	50.229	27.925	28.818	.01736	.78966	3.100
2.20	47.614	31.917	32.917	.01983	.88415	3.039
2.40	45.309	36.119	37.229	.02243	.98256	2.982
2.60	43.260	40.526	41.749	.02515	1.0846	2.930
2.80	41.427	45.137	46.476	.02800	1.1900	2.881
3.00	39.771	49.944	51.402	.03096	1.2985	2.836
3.20	38.263	54.946	56.525	.03405	1.4101	2.793
3.40	36.883	60.142	61.846	.03726	1.5247	2.755
3.60	35.585	65.533	67.363	.04058	1.6423	2.718
3.80	34.450	71.116	73.077	.04402	1.7628	2.683
4.00	33.396	76.888	78.901	.04758	1.8857	2.651
4.20	32.415	82.828	85.057	.05124	2.0111	2.621
4.40	31.499	88.965	91.332	.05502	2.1388	2.592
4.60	30.642	95.254	97.762	.05889	2.2690	2.565
4.80	29.839	101.73	104.38	.06288	2.4016	2.540
5.00	29.081	108.48	112.24	.06700	2.5360	2.516
5.20	28.367	115.54	120.38	.07126	2.6720	2.493
5.40	27.696	122.92	128.79	.07566	2.8090	2.471
5.60	27.067	130.56	137.46	.08020	2.9470	2.449
5.80	26.478	138.46	146.39	.08488	3.0860	2.428
6.00	25.928	146.62	155.58	.08969	3.2260	2.408
6.20	25.416	155.04	165.02	.09463	3.3670	2.388
6.40	24.941	163.72	174.71	.09970	3.5090	2.368
6.60	24.501	172.66	184.65	.10490	3.6520	2.348
6.80	24.096	181.86	194.84	.11022	3.7960	2.328
7.00	23.725	191.32	205.28	.11566	3.9410	2.308
7.20	23.387	201.03	215.97	.12122	4.0870	2.288
7.40	23.081	210.99	226.90	.12690	4.2340	2.268
7.60	22.806	221.20	238.07	.13269	4.3820	2.248
7.80	22.561	231.66	249.48	.13859	4.5310	2.228
8.00	22.345	242.37	261.13	.14460	4.6810	2.208
8.20	22.157	253.32	273.02	.15072	4.8320	2.188
8.40	21.996	264.52	285.15	.15695	4.9840	2.168
8.60	21.861	275.97	297.52	.16329	5.1370	2.148
8.80	21.751	287.67	310.13	.16974	5.2910	2.128
9.00	21.665	299.62	323.00	.17629	5.4460	2.108
9.20	21.602	311.82	336.13	.18294	5.6010	2.088
9.40	21.560	324.26	349.52	.18969	5.7570	2.068
9.60	21.537	336.94	363.17	.19654	5.9140	2.048
9.80	21.532	349.86	377.08	.20349	6.0710	2.028
10.00	21.544	363.02	391.25	.21054	6.2290	2.008

## TANTALUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM <sup>2</sup>	MEV/CM	GM/CM <sup>2</sup>	CM	GM/CM <sup>2</sup>	CM	GM/CM <sup>2</sup>	CM		
5.00	29.084	482.80	.10837	.00653	.11117	.00670	.00254	.00015	2.325	0.
5.50	27.383	454.56	.12573	.00757	.12050	.00777	.00209	.00017	2.461	0.
6.00	25.902	429.98	.14411	.00868	.14768	.00900	.00326	.00020	2.412	0.
6.50	24.601	408.37	.16354	.00985	.16751	.01009	.00364	.00022	2.369	.00032
7.00	23.442	389.14	.18395	.01108	.18834	.01135	.00405	.00024	2.330	.00005
7.50	22.422	372.20	.20553	.01237	.21015	.01266	.00447	.00027	2.294	.00009
8.00	21.501	356.92	.22766	.01371	.23293	.01403	.00490	.00030	2.262	.00011
8.50	20.666	343.06	.25092	.01512	.25665	.01546	.00535	.00032	2.233	.00012
9.00	19.902	330.33	.27510	.01657	.28131	.01695	.00581	.00035	2.206	.00012
9.50	19.207	318.83	.30021	.01808	.30690	.01849	.00628	.00038	2.181	.00012
10.00	18.566	308.20	.32619	.01965	.33338	.02008	.00676	.00041	2.157	.00013
11.00	17.423	289.22	.38079	.02294	.38902	.02343	.00777	.00047	2.116	.00015
12.00	16.435	272.81	.43884	.02644	.44815	.02700	.00881	.00053	2.079	.00018
13.00	15.569	258.41	.50025	.03014	.51070	.03077	.00991	.00060	2.046	.00024
14.00	14.802	245.72	.56496	.03403	.57660	.03473	.01104	.00067	2.017	.00030
15.00	14.119	234.30	.63293	.03813	.64579	.03890	.01222	.00074	1.991	.00040
16.00	13.506	224.20	.70410	.04242	.71823	.04327	.01344	.00081	1.967	.00051
17.00	12.952	215.00	.77842	.04689	.79386	.04782	.01469	.00089	1.945	.00065
18.00	12.448	206.64	.85585	.05156	.87265	.05257	.01599	.00096	1.925	.00081
19.00	11.988	199.01	.93632	.05640	.95452	.05756	.01732	.00104	1.907	.00099
20.00	11.566	192.00	1.0198	.06144	1.0395	.06262	.01870	.00113	1.890	.00120
22.00	10.828	179.58	1.1957	.07203	1.2184	.07340	.02155	.00130	1.859	.00168
24.00	10.172	168.86	1.3833	.08333	1.4092	.08489	.02455	.00148	1.832	.00224
26.00	9.6394	160.01	1.5821	.09531	1.6112	.09706	.02767	.00167	1.808	.00322
28.00	9.1478	151.85	1.7917	.10793	1.8243	.10990	.03092	.00186	1.787	.00462
30.00	8.7113	144.61	2.0121	.12121	2.0483	.12339	.03431	.00207	1.768	.00607
32.00	8.3193	138.10	2.2434	.13514	2.2834	.13755	.03781	.00228	1.751	.00757
34.00	7.9694	132.29	2.4853	.14972	2.5292	.15236	.04145	.00250	1.735	.00913
36.00	7.6523	127.03	2.7373	.16490	2.7852	.16778	.04523	.00272	1.721	.01074
38.00	7.3630	122.23	2.9994	.18069	3.0515	.18383	.04913	.00296	1.707	.01240
40.00	7.0990	117.84	3.2721	.19712	3.3286	.20052	.05316	.00320	1.695	.01411
45.00	6.5268	108.35	3.9958	.24071	4.0635	.24479	.06375	.00384	1.668	.01855
50.00	6.0536	100.49	4.7798	.28794	4.8597	.29276	.07507	.00452	1.645	.02324
55.00	5.6553	94.878	5.6222	.33869	5.7152	.34429	.08708	.00525	1.626	.02817
60.00	5.3154	88.236	6.5208	.39282	6.6274	.39924	.09974	.00601	1.609	.03334
65.00	5.0217	83.360	7.4730	.45016	7.5941	.45748	.11303	.00681	1.595	.03875
70.00	4.7648	79.096	8.4801	.51085	8.6164	.51904	.12692	.00765	1.582	.04436
75.00	4.5380	75.331	9.5398	.57469	9.6921	.58386	.14140	.00852	1.570	.05017
80.00	4.3359	71.975	10.651	.64161	10.820	.65178	.15644	.00942	1.560	.05615
90.00	3.9956	66.326	13.019	.78427	13.223	.79655	.18813	.01133	1.542	.06857



## TANTALUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CH2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	3.7164	15.578	15.820	.95298	.22181	.01336	1.402	.08150
110.00	3.4833	18.319	18.601	1.1205	.25737	.01550	1.384	.09493
120.00	3.2854	21.254	21.556	1.2985	.29471	.01775	1.367	.10853
130.00	3.1155	24.314	24.683	1.4869	.33371	.02010	1.352	.12326
140.00	2.9678	27.556	27.972	1.6851	.37430	.02255	1.338	.13800
150.00	2.8383	30.954	31.419	1.8927	.41639	.02508	1.325	.15304
160.00	2.7238	34.500	35.016	2.1094	.45990	.02771	1.313	.16837
170.00	2.6219	38.190	38.759	2.3349	.50476	.03041	1.302	.18401
180.00	2.5305	42.018	42.642	2.5688	.55090	.03319	1.292	.19990
190.00	2.4482	45.977	46.658	2.8107	.59825	.03604	1.282	.21599
200.00	2.3758	50.088	50.808	3.0607	.64676	.03896	1.273	.23223
210.00	2.3078	54.277	55.077	3.3179	.69624	.04194	1.266	.24855
220.00	2.2456	58.612	59.473	3.5827	.74679	.04499	1.252	.26490
230.00	2.1886	63.051	63.976	3.8540	.79835	.04809	1.240	.28124
240.00	2.1361	67.615	68.605	4.1328	.85088	.05126	1.230	.29753
250.00	2.0877	72.287	73.343	4.4183	.90433	.05448	1.223	.31375
260.00	2.0429	77.064	78.188	4.7101	.95866	.05775	1.226	.32987
270.00	2.0013	81.943	83.136	5.0082	1.0138	.06107	1.219	.34585
280.00	1.9626	86.905	88.169	5.3114	1.0698	.06445	1.213	.36167
290.00	1.9265	91.979	93.315	5.6214	1.1265	.06786	1.207	.37731
300.00	1.8918	97.144	98.553	5.9370	1.1840	.07133	1.201	.39276
310.00	1.8602	102.41	103.89	6.2584	1.2423	.07484	1.196	.40807
320.00	1.8306	107.75	109.31	6.5848	1.3012	.07839	1.190	.42327
330.00	1.8028	113.18	114.81	6.9164	1.3608	.08197	1.185	.43836
340.00	1.7765	118.69	120.40	7.2530	1.4210	.08560	1.180	.45330
350.00	1.7518	124.27	126.07	7.5944	1.4817	.08926	1.175	.46809
360.00	1.7285	129.98	131.86	7.9432	1.5431	.09296	1.170	.48272
370.00	1.7065	135.70	137.65	8.2921	1.6050	.09668	1.166	.49719
380.00	1.6856	141.50	143.53	8.6465	1.6674	.10044	1.162	.51149
390.00	1.6658	147.38	149.50	9.0060	1.7303	.10423	1.157	.52560
400.00	1.6470	153.33	155.54	9.3696	1.7936	.10805	1.153	.53951
410.00	1.6292	159.35	161.64	9.7373	1.8575	.11190	1.149	.55320
420.00	1.6122	165.44	167.81	10.109	1.9218	.11577	1.145	.56684
430.00	1.5960	171.58	174.04	10.484	1.9865	.11967	1.141	.57984
440.00	1.5807	177.79	180.34	10.864	2.0516	.12359	1.138	.59278
450.00	1.5660	184.06	186.62	11.246	2.1172	.12754	1.134	.60546
460.00	1.5520	190.38	193.10	11.633	2.1831	.13151	1.131	.61788
470.00	1.5386	196.76	199.57	12.023	2.2493	.13550	1.127	.63003
480.00	1.5258	203.20	206.10	12.416	2.3160	.13952	1.124	.64191
490.00	1.5136	209.69	212.68	12.812	2.3829	.14355	1.120	.65353

# TANTALUM

PROTON ENERGY MEV	ENERGY LOSS HEV/CM	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.5019	24.932	219.34	13.213	2.4502	.14760	1.406	.66488
510.00	1.4907	24.745	226.02	13.616	2.5178	.15168	1.405	.67595
520.00	1.4799	24.567	232.75	14.021	2.5858	.15577	1.405	.68676
530.00	1.4696	24.396	239.53	14.430	2.6540	.15988	1.404	.69729
540.00	1.4598	24.232	246.36	14.841	2.7225	.16400	1.403	.70756
550.00	1.4503	24.074	253.23	15.255	2.7912	.16815	1.402	.71756
560.00	1.4411	23.923	260.15	15.672	2.8603	.17231	1.401	.72730
570.00	1.4324	23.777	267.11	16.091	2.9296	.17648	1.401	.73677
580.00	1.4239	23.637	274.11	16.513	2.9991	.18067	1.400	.74599
590.00	1.4158	23.502	281.15	16.937	3.0689	.18487	1.399	.75494
600.00	1.4080	23.373	288.23	17.363	3.1389	.18909	1.398	.76365
620.00	1.3932	23.127	302.51	18.223	3.2795	.19756	1.397	.78031
640.00	1.3795	22.900	316.94	19.092	3.4210	.20609	1.395	.79600
660.00	1.3667	22.688	331.50	19.970	3.5633	.21466	1.394	.81075
680.00	1.3548	22.490	346.20	20.855	3.7063	.22327	1.393	.82460
700.00	1.3437	22.306	361.02	21.748	3.8500	.23193	1.391	.83758
720.00	1.3333	22.134	375.96	22.648	3.9944	.24063	1.390	.84973
740.00	1.3236	21.973	391.05	23.557	4.1393	.24936	1.388	.86109
760.00	1.3146	21.822	406.35	24.479	4.2849	.25812	1.386	.87170
780.00	1.3061	21.681	421.62	25.399	4.4309	.26692	1.385	.88159
800.00	1.2981	21.548	436.99	26.325	4.5775	.27575	1.384	.89080
820.00	1.2906	21.424	452.45	27.256	4.7245	.28461	1.382	.89937
840.00	1.2835	21.307	468.00	28.193	4.8720	.29350	1.381	.90734
860.00	1.2769	21.197	483.63	29.135	5.0200	.30241	1.379	.91473
880.00	1.2707	21.094	499.35	30.081	5.1683	.31134	1.378	.92159
900.00	1.2649	20.997	515.14	31.033	5.3170	.32030	1.376	.92795
920.00	1.2593	20.905	531.02	31.989	5.4661	.32928	1.375	.93383
940.00	1.2541	20.819	546.96	32.950	5.6156	.33829	1.373	.93927
960.00	1.2492	20.737	563.00	33.915	5.7653	.34731	1.370	.94430
1000.00	1.2403	20.588	595.43	35.869	6.0658	.36541	1.364	.95318

THE ELECTRON DENSITY OF TANTALUM IS 2.431E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.937 BEV, AND THE MINIMUM ENERGY LOSS IS 1.1754 MEV/GM/CM2

THORIUM

ATOMIC NUMBER 90  
 ATOMS/MOLECULE 1  
 ATOMIC WEIGHT 232.04  
 ADJUSTED IONIZATION POTENTIAL 888.8

DENSITY = 11.500 GM/CM3

PROCTON ENERGY MEV	ENERGY LOSS MEV/CM2	ENERGY LOSS MEV/CH	PROTON RANGE HG/CH2	PROTON PATH LENGTH HG/CH2	PROTON PATH LENGTH MM	HG/CH2	PATH LENGTH STRAGGLING MM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	120.09	1381.1	1.4063	.00122	.00130	.07748	.00007	5.187	5.832	0.
.15	125.62	1444.6	1.8080	.00157	.00165	.08969	.00008	4.719	4.835	0.
.20	124.24	1428.8	2.1993	.00191	.00200	.10019	.00009	4.354	4.413	0.
.30	111.50	1282.3	3.0188	.00263	.00274	.12136	.00011	3.856	4.082	0.
.40	98.322	1130.7	3.9420	.00343	.00357	.14674	.00013	3.576	3.946	0.
.50	88.969	1023.1	4.9743	.00433	.00450	.17890	.00016	3.457	3.873	0.
.60	81.407	936.17	6.1074	.00531	.00552	.21573	.00019	3.397	3.825	0.
.70	75.931	873.21	7.3334	.00638	.00663	.25548	.00022	3.352	3.786	0.
.80	69.938	804.29	8.6569	.00753	.00782	.29819	.00026	3.315	3.751	0.
.90	66.006	759.07	10.076	.00876	.00910	.34358	.00030	3.283	3.719	0.
1.00	62.065	713.75	11.584	.01007	.01046	.39081	.00034	3.249	3.690	0.
1.20	56.498	649.73	14.849	.01291	.01340	.48984	.00043	3.179	3.635	0.
1.40	52.088	599.02	18.416	.01601	.01661	.59280	.00052	3.104	3.584	0.
1.60	48.500	557.75	22.268	.01936	.02007	.69940	.00061	3.030	3.536	0.
1.80	45.510	523.37	26.391	.02295	.02378	.80940	.00070	2.960	3.491	0.
2.00	42.967	494.12	30.771	.02676	.02771	.92303	.00080	2.896	3.449	0.
2.20	40.759	468.73	35.401	.03078	.03187	1.04330	.00091	2.846	3.408	0.
2.40	38.939	446.64	40.275	.03502	.03624	1.1687	.00102	2.804	3.370	0.
2.60	37.133	427.03	45.383	.03946	.04082	1.2994	.00113	2.768	3.334	0.
2.80	35.604	409.45	50.720	.04410	.04561	1.4344	.00125	2.735	3.300	0.
3.00	34.225	393.58	56.280	.04894	.05059	1.5735	.00137	2.705	3.267	0.
3.20	32.972	379.17	62.060	.05397	.05577	1.7163	.00149	2.676	3.236	0.
3.40	31.831	366.06	68.056	.05918	.06114	1.8625	.00162	2.649	3.207	0.
3.60	30.787	354.05	74.264	.06458	.06670	2.0120	.00175	2.623	3.179	0.
3.80	29.827	343.01	80.677	.07015	.07244	2.1645	.00188	2.598	3.152	0.
4.00	28.978	333.24	87.293	.07591	.07836	2.3199	.00202	2.575	3.127	0.
4.20	28.150	323.73	94.105	.08183	.08445	2.4776	.00215	2.551	3.103	0.
4.40	27.378	314.35	101.10	.08792	.09071	2.6382	.00229	2.529	3.079	0.
4.60	26.655	306.53	108.30	.09417	.09714	2.8015	.00244	2.508	3.057	0.
4.80	25.979	298.76	115.70	.10061	.10376	2.9675	.00258	2.487	3.036	0.

# THORIUM

FRAC TION ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE CM	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING CM	GM/CM2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	25.310	0.1072	.12713	.00314	.00627	2.467	3.015	0.
5.50	23.916	0.1244	.14745	.00357	.00031	2.421	2.967	0.
6.00	22.691	0.1426	.16892	.00402	.00035	2.378	2.924	0.
6.50	21.605	0.1617	.19152	.00448	.00039	2.338	2.884	0.
7.00	20.634	0.1818	.21520	.00495	.00043	2.301	2.847	0.
7.50	19.762	0.2028	.23997	.00544	.00047	2.267	2.813	0.
8.00	18.973	0.2247	.26581	.00594	.00052	2.235	2.781	0.
8.50	18.255	0.2475	.29268	.00646	.00056	2.206	2.751	0.
9.00	17.599	0.2712	.32057	.00699	.00061	2.179	2.724	0.
9.50	16.996	0.2957	.34949	.00753	.00065	2.155	2.698	0.
10.00	16.440	0.3211	.37942	.00809	.00070	2.133	2.673	0.
11.00	15.445	0.3745	.44225	.00927	.00081	2.096	2.629	.00001
12.00	14.597	0.4310	.50887	.01050	.00091	2.063	2.589	.00002
13.00	13.850	0.4908	.57922	.01178	.00102	2.034	2.553	.00004
14.00	13.191	0.5537	.65326	.01312	.00114	2.008	2.520	.00008
15.00	12.601	0.6197	.73081	.01450	.00126	1.984	2.491	.00014
16.00	12.066	0.6886	.81194	.01592	.00138	1.961	2.463	.00021
17.00	11.590	0.7606	.89658	.01740	.00151	1.941	2.438	.00030
18.00	11.156	0.8354	.98450	.01891	.00164	1.921	2.414	.00042
19.00	10.758	0.9131	1.0758	.02047	.00178	1.903	2.393	.00055
20.00	10.391	0.9936	1.1704	.02207	.00192	1.886	2.372	.00071
22.00	9.7415	1.1629	1.3694	.02539	.00221	1.854	2.335	.00109
24.00	9.2211	1.3427	1.5805	.02885	.00251	1.825	2.303	.00155
26.00	8.7238	1.5327	1.8036	.03243	.00282	1.798	2.273	.00247
28.00	8.2852	1.7331	2.0389	.03617	.00314	1.774	2.247	.00385
30.00	7.8965	1.9439	2.2864	.04005	.00348	1.752	2.223	.00528
32.00	7.5488	2.1650	2.5458	.04409	.00383	1.732	2.201	.00677
34.00	7.2355	2.3955	2.8163	.04826	.00420	1.713	2.181	.00831
36.00	6.9515	2.6357	3.0980	.05256	.00457	1.697	2.162	.00990
38.00	6.6930	2.8862	3.3919	.05701	.00496	1.681	2.145	.01153
40.00	6.4541	3.1453	3.6959	.06158	.00535	1.666	2.130	.01321
45.00	5.9453	3.8346	4.5042	.07356	.00640	1.633	2.095	.01760
50.00	5.5237	4.5795	5.3775	.08627	.00750	1.604	2.065	.02222
55.00	5.1791	5.3776	6.3130	.09961	.00866	1.578	2.040	.02706
60.00	4.8736	6.2275	7.3088	.11368	.00989	1.553	2.017	.03215
65.00	4.6088	7.1272	8.3637	.12848	.01117	1.536	1.998	.03746
70.00	4.3774	8.0774	9.4767	.14394	.01252	1.519	1.980	.04298
75.00	4.1730	9.0761	10.647	.16006	.01392	1.503	1.965	.04869
80.00	3.9911	1.0123	11.873	.17619	.01537	1.489	1.951	.05458
90.00	3.6810	1.2354	14.486	.21203	.01844	1.464	1.927	.06682

# THORIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CH2	CM	GM/CH2	CM	GM/CH2	CM		
100.00	3.4267	16.974	1.4763	17.303	1.5047	.24949	.02170	1.907	.07959
110.00	3.2136	19.935	1.7334	20.319	1.7668	.28903	.02513	1.890	.09287
120.00	3.0330	23.070	2.0061	23.511	2.0444	.33053	.02874	1.876	.10667
130.00	2.8774	26.397	2.2954	26.898	2.3390	.37387	.03251	1.864	.12091
140.00	2.7429	29.894	2.5994	30.458	2.6485	.41892	.03643	1.853	.13552
150.00	2.6248	33.556	2.9179	34.186	2.9727	.46559	.04049	1.843	.15044
160.00	2.5202	37.375	3.2500	38.074	3.3108	.51378	.04468	1.835	.16561
170.00	2.4270	41.337	3.5945	42.106	3.6614	.56342	.04899	1.826	.18100
180.00	2.3435	45.455	3.9526	46.298	4.0259	.61444	.05343	1.820	.19656
190.00	2.2681	49.717	4.3232	50.635	4.4030	.66677	.05798	1.814	.21324
200.00	2.1998	54.116	4.7038	55.113	4.7924	.72035	.06264	1.808	.22799
210.00	2.1377	58.646	5.0996	59.723	5.1933	.77511	.06740	1.803	.24384
220.00	2.0800	63.305	5.5048	64.465	5.6056	.83099	.07226	1.799	.25978
230.00	2.0207	68.087	5.9206	69.331	6.0287	.88796	.07721	1.794	.27579
240.00	1.9629	72.988	6.3468	74.319	6.4625	.94593	.08225	1.791	.29183
250.00	1.9384	77.996	6.7822	79.415	6.9056	1.0047	.08737	1.787	.30786
260.00	1.8972	83.123	7.2281	84.632	7.3593	1.0644	.09256	1.784	.32384
270.00	1.8590	88.361	7.6836	89.963	7.8229	1.1251	.09783	1.781	.33974
280.00	1.8234	93.680	8.1461	95.376	8.2936	1.1866	.10318	1.778	.35552
290.00	1.7902	99.123	8.6194	100.91	8.7752	1.2489	.10860	1.775	.37118
300.00	1.7592	104.65	9.1002	106.54	9.2644	1.3121	.11409	1.772	.38668
310.00	1.7301	110.29	9.5903	112.28	9.7631	1.3759	.11965	1.770	.40203
320.00	1.7028	116.02	10.088	118.11	10.270	1.4405	.12526	1.768	.41725
330.00	1.6772	121.84	10.594	124.03	10.785	1.5058	.13094	1.765	.43230
340.00	1.6531	127.74	11.108	130.03	11.307	1.5718	.13668	1.763	.44738
350.00	1.6303	133.73	11.629	136.13	11.837	1.6384	.14247	1.761	.46167
360.00	1.6077	139.77	12.154	142.27	12.371	1.7056	.14832	1.760	.47638
370.00	1.5874	145.93	12.690	148.54	12.917	1.7736	.15422	1.758	.49070
380.00	1.5682	152.16	13.231	154.88	13.468	1.8420	.16018	1.757	.50483
390.00	1.5500	158.46	13.779	161.29	14.025	1.9110	.16618	1.755	.51874
400.00	1.5327	164.83	14.333	167.77	14.589	1.9806	.17222	1.753	.53243
410.00	1.5163	171.28	14.894	174.33	15.159	2.0506	.17831	1.752	.54590
420.00	1.5007	177.79	15.460	180.96	15.735	2.1211	.18444	1.751	.55915
430.00	1.4858	184.37	16.032	187.65	16.318	2.1920	.19061	1.749	.57218
440.00	1.4717	191.12	16.619	194.51	16.914	2.2634	.19681	1.747	.58497
450.00	1.4581	197.83	17.202	201.34	17.508	2.3352	.20306	1.746	.59752
460.00	1.4453	204.60	17.791	208.23	18.107	2.4074	.20934	1.745	.60983
470.00	1.4330	211.43	18.385	215.18	18.711	2.4799	.21565	1.744	.62189
480.00	1.4212	218.32	18.954	222.19	19.321	2.5529	.22199	1.742	.63370
490.00	1.4100	225.26	19.588	229.25	19.935	2.6262	.22837	1.741	.64527

# THORIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.3992	232.26	236.37	20.554	2.6999	.23477	1.740	.65657
510.00	1.3889	239.31	243.54	21.178	2.7739	.24121	1.739	.66763
520.00	1.3790	246.41	250.77	21.806	2.8482	.24767	1.738	.67843
530.00	1.3695	253.57	258.05	22.439	2.9228	.25416	1.737	.68897
540.00	1.3604	260.77	265.37	23.076	2.9978	.26067	1.736	.69926
550.00	1.3517	268.02	272.75	23.717	3.0730	.26722	1.735	.70930
560.00	1.3433	275.31	280.17	24.363	3.1485	.27378	1.734	.71908
570.00	1.3352	282.65	287.64	25.012	3.2242	.28037	1.733	.72861
580.00	1.3275	290.04	295.15	25.665	3.3002	.28698	1.732	.73789
590.00	1.3200	297.46	302.70	26.322	3.3765	.29361	1.731	.74693
600.00	1.3128	304.93	310.30	26.983	3.4530	.30026	1.730	.75572
620.00	1.2992	319.99	325.61	28.314	3.6067	.31363	1.729	.77258
640.00	1.2866	335.20	341.08	29.660	3.7613	.32707	1.727	.78849
660.00	1.2749	350.55	356.70	31.017	3.9167	.34058	1.725	.80350
680.00	1.2640	366.04	372.46	32.388	4.0729	.35416	1.723	.81761
700.00	1.2538	381.66	388.35	33.769	4.2297	.36780	1.721	.83088
720.00	1.2443	397.42	404.37	35.163	4.3873	.38150	1.720	.84332
740.00	1.2354	413.28	420.50	36.566	4.5454	.39525	1.718	.85498
760.00	1.2270	429.25	436.75	37.978	4.7042	.40906	1.716	.86589
780.00	1.2193	445.42	453.19	39.408	4.8635	.42291	1.714	.87609
800.00	1.2119	461.60	469.64	40.839	5.0233	.43681	1.712	.88560
820.00	1.2051	477.88	486.20	42.278	5.1836	.45075	1.710	.89447
840.00	1.1987	494.27	502.86	43.727	5.3443	.46473	1.709	.90273
860.00	1.1926	510.73	519.60	45.182	5.5055	.47874	1.707	.91042
880.00	1.1869	527.16	536.31	46.636	5.6672	.49280	1.706	.91755
900.00	1.1816	543.79	553.22	48.106	5.8292	.50688	1.704	.92418
920.00	1.1765	560.48	570.18	49.581	5.9915	.52100	1.702	.93032
940.00	1.1718	577.25	587.23	51.063	6.1543	.53515	1.700	.93601
960.00	1.1673	594.10	604.35	52.553	6.3173	.54933	1.697	.94127
1000.00	1.1592	628.39	639.22	55.584	6.6444	.57777	1.694	.95057

THE ELECTRON DENSITY OF THORIUM IS 2.337E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.900 BEV, AND THE MINIMUM ENERGY LOSS IS 1.1025 MEV/GM/CM2

# TIN

ATOMIC NUMBER 50  
ELEMENT SN  
ATOMS/MOLECULE 1  
ADJUSTED IONIZATION POTENTIAL 483.0  
ATOMIC WEIGHT 118.69

DENSITY = 7.2980 GM/CM3

PHOTON ENERGY MEV	ENERGY LOSS GM/CM2	PROTON RANGE MG/CM2	PROTON PATH LENGTH MG/CM2	MG/CM2	PATH LENGTH STRAGGLING MM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	247.80	.82723	.00113	.85914	.04103	.00006	3.713	0.
.15	224.06	1.0379	.00142	1.0712	.04485	.00006	3.115	0.
.20	203.28	1.2687	.00174	1.3054	.04939	.00007	2.811	0.
.30	169.56	1.7986	.00246	1.8450	.06088	.00008	2.515	0.
.40	145.09	2.4249	.00332	2.4838	.07724	.00011	2.372	0.
.50	127.69	3.1464	.00431	3.2200	.09847	.00013	2.288	0.
.60	115.61	3.9543	.00542	4.0446	.12275	.00017	2.231	0.
.70	106.97	4.8367	.00663	4.9444	.14868	.00020	2.189	0.
.80	99.919	5.7854	.00793	5.9127	.17557	.00024	2.154	0.
.90	94.257	6.7950	.00931	6.9424	.20321	.00028	2.123	0.
1.00	88.591	7.8687	.01078	8.0372	.23182	.00032	2.096	0.
1.20	73.486	10.195	.01397	10.408	.29171	.00040	2.047	0.
1.40	63.924	12.744	.01746	13.005	.35424	.00049	2.004	0.
1.60	56.640	15.506	.02125	15.817	.41942	.00057	1.965	0.
1.80	50.259	18.468	.02531	18.832	.48690	.00067	1.930	0.
2.00	44.160	21.621	.02963	22.040	.55685	.00076	1.898	0.
2.20	39.730	24.963	.03421	25.439	.63068	.00086	1.868	0.
2.40	36.099	28.489	.03904	29.023	.70824	.00097	1.841	0.
2.60	32.916	32.191	.04411	32.784	.78902	.00108	1.816	0.
2.80	30.150	36.064	.04942	36.722	.87270	.00120	1.792	0.
3.00	27.710	40.107	.05496	40.830	.95907	.00131	1.770	0.
3.20	25.592	44.317	.06072	45.106	1.0480	.00144	1.750	0.
3.40	23.734	48.687	.06671	49.544	1.1392	.00156	1.730	0.
3.60	22.113	53.221	.07293	54.148	1.2328	.00169	1.712	0.
3.80	20.699	57.911	.07935	58.910	1.3286	.00182	1.695	0.
4.00	19.446	62.757	.08599	63.828	1.4266	.00195	1.678	0.
4.20	18.333	67.759	.09285	68.905	1.5267	.00209	1.663	0.
4.40	17.342	72.912	.09991	74.134	1.6288	.00223	1.648	0.
4.60	16.435	78.216	.10717	79.516	1.7330	.00237	1.634	0.
4.80	15.664	83.672	.11465	85.050	1.8392	.00252	1.621	0.

TIN

PRCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING		PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM	PERCENT	PERCENT	
5.00	34.740	253.53	.08927	.01223	.09073	.01243	.00195	.00027	2.146	1.608	0.
5.50	32.739	238.93	.10390	.01424	.10557	.01447	.00223	.00030	2.108	1.579	0.
6.00	30.926	225.70	.11941	.01636	.12130	.01662	.00251	.00034	2.073	1.553	0.
6.50	29.332	214.07	.13580	.01861	.13791	.01890	.00282	.00039	2.042	1.529	.00001
7.00	27.916	203.73	.15304	.02097	.15538	.02129	.00313	.00043	2.013	1.507	.00001
7.50	26.650	194.49	.17114	.02345	.17372	.02380	.00345	.00047	1.987	1.487	.00002
8.00	25.503	186.12	.19007	.02604	.19290	.02643	.00379	.00052	1.962	1.469	.00003
8.50	24.490	178.73	.20983	.02875	.21292	.02918	.00413	.00057	1.940	1.452	.00004
9.00	23.566	171.98	.23038	.03157	.23374	.03203	.00448	.00061	1.919	1.436	.00006
9.50	22.719	165.80	.25172	.03449	.25535	.03499	.00485	.00066	1.899	1.422	.00008
10.00	21.938	160.11	.27382	.03752	.27773	.03806	.00522	.00072	1.880	1.408	.00011
11.00	20.548	149.94	.32038	.04390	.32487	.04452	.00600	.00082	1.846	1.384	.00018
12.00	19.342	141.16	.36995	.05069	.37506	.05139	.00681	.00093	1.816	1.362	.00028
13.00	18.299	133.54	.42250	.05789	.42824	.05868	.00766	.00105	1.789	1.342	.00040
14.00	17.376	126.81	.47793	.06549	.48435	.06637	.00855	.00117	1.765	1.325	.00055
15.00	16.553	120.80	.53622	.07347	.54333	.07445	.00947	.00130	1.743	1.309	.00072
16.00	15.815	115.42	.59731	.08185	.60514	.08292	.01043	.00143	1.724	1.294	.00092
17.00	15.148	110.55	.66119	.09060	.66977	.09177	.01143	.00157	1.707	1.281	.00114
18.00	14.542	106.13	.72783	.09973	.73718	.10101	.01247	.00171	1.691	1.269	.00138
19.00	13.988	102.09	.79715	.10923	.80730	.11062	.01354	.00186	1.677	1.257	.00165
20.00	13.481	98.381	.86918	.11910	.88016	.12060	.01465	.00201	1.664	1.247	.00193
22.00	12.581	91.815	1.0211	.13992	1.0338	.14166	.01696	.00232	1.640	1.228	.00313
24.00	11.808	86.175	1.1835	.16217	1.1980	.16416	.01940	.00266	1.619	1.211	.00911
26.00	11.137	81.276	1.3561	.18582	1.3726	.18808	.02197	.00301	1.601	1.197	.01185
28.00	10.547	76.971	1.5388	.21085	1.5572	.21337	.02466	.00338	1.584	1.184	.01327
30.00	10.026	73.168	1.7312	.23722	1.7518	.24004	.02748	.00376	1.568	1.172	.01476
32.00	9.5605	69.773	1.9334	.26492	1.9561	.26804	.03041	.00417	1.554	1.161	.01630
34.00	9.1420	66.718	2.1452	.29394	2.1702	.29737	.03345	.00458	1.541	1.152	.01790
36.00	8.7653	63.969	2.3664	.32425	2.3937	.32800	.03600	.00502	1.529	1.143	.01955
38.00	8.4213	61.458	2.5968	.35582	2.6266	.35990	.03987	.00546	1.518	1.135	.02125
40.00	8.1104	59.190	2.8363	.38865	2.8687	.39308	.04324	.00592	1.507	1.127	.02300
45.00	7.4388	54.284	3.4742	.47604	3.5132	.48139	.05210	.00714	1.483	1.111	.02755
50.00	6.8858	50.253	4.1662	.57089	4.2125	.57721	.06158	.00844	1.462	1.098	.03234
55.00	6.4217	46.866	4.9111	.67293	4.9650	.68032	.07165	.00982	1.443	1.086	.03738
60.00	6.0265	43.982	5.7073	.78203	5.7693	.79054	.08229	.01128	1.426	1.076	.04267
65.00	5.6856	41.494	6.5534	.89797	6.6241	.90765	.09347	.01281	1.411	1.067	.04819
70.00	5.3884	39.325	7.4481	1.0206	7.5279	1.0315	.10519	.01441	1.397	1.059	.05393
75.00	5.1269	37.416	8.3902	1.1497	8.4794	1.1619	.11741	.01609	1.385	1.053	.05986
80.00	4.8949	35.723	9.3789	1.2851	9.4781	1.2987	.13012	.01783	1.373	1.047	.06596
90.00	4.5012	32.850	11.491	1.5745	11.611	1.5910	.15696	.02151	1.352	1.036	.07862



## TIN

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	4.1796	13.776	13.919	.18558	.02543	1.027	.09178
110.00	3.9117	16.227	16.394	.21588	.02958	1.020	.10544
120.00	3.6849	18.837	19.035	.24777	.03395	1.014	.11960
130.00	3.4928	21.599	21.820	.28114	.03852	1.009	.13419
140.00	3.3239	24.508	24.756	.31588	.04328	1.004	.14912
150.00	3.1758	27.556	27.834	.35196	.04823	.999	.16433
160.00	3.0451	30.743	31.053	.38933	.05335	.993	.17982
170.00	2.9290	34.058	34.400	.42791	.05863	.993	.19557
180.00	2.8250	37.503	37.879	.46764	.06408	.992	.21153
190.00	2.7313	41.071	41.481	.50846	.06967	.9876	.22756
200.00	2.6465	44.754	45.200	.55033	.07541	.9852	.24390
210.00	2.5695	48.553	49.035	.59320	.08128	.9830	.26019
220.00	2.4985	52.463	52.982	.63702	.08729	.9811	.27645
230.00	2.4340	56.481	57.040	.68177	.09342	.9793	.29266
240.00	2.3747	60.598	61.197	.72738	.09967	.9776	.30878
250.00	2.3200	64.819	65.458	.77382	.10603	.9761	.32477
260.00	2.2693	69.139	69.820	.82104	.11250	.9746	.34071
270.00	2.2223	73.550	74.273	.86902	.11908	.9733	.35667
280.00	2.1786	78.052	78.818	.91773	.12575	.9720	.37261
290.00	2.1379	82.642	83.452	.96712	.13252	.9709	.38851
300.00	2.0998	87.313	88.168	1.0172	.13938	.9693	.40435
310.00	2.0642	92.071	92.972	1.0679	.14632	.9687	.42008
320.00	2.0307	96.914	97.861	1.1192	.15335	.9677	.43555
330.00	1.9993	101.83	102.82	1.1710	.16046	.9668	.45104
340.00	1.9697	106.82	107.86	1.2235	.16765	.9658	.46624
350.00	1.9418	111.89	112.98	1.2765	.17490	.9650	.48124
360.00	1.9155	117.02	118.16	1.3299	.18223	.9642	.49603
370.00	1.8906	122.23	123.42	1.3839	.18963	.9634	.51060
380.00	1.8671	127.50	128.74	1.4384	.19710	.9627	.52495
390.00	1.8447	132.84	134.13	1.4933	.20462	.9619	.53907
400.00	1.8235	138.24	139.58	1.5487	.21221	.9612	.55294
410.00	1.8034	143.70	145.09	1.6045	.21985	.9605	.56656
420.00	1.7845	149.22	150.67	1.6607	.22756	.9598	.57994
430.00	1.7660	154.80	156.30	1.7173	.23531	.9592	.59306
440.00	1.7487	160.44	161.99	1.7743	.24312	.9585	.60593
450.00	1.7321	166.13	167.74	1.8316	.25097	.9579	.61853
460.00	1.7163	171.88	173.54	1.8893	.25888	.9573	.63086
470.00	1.7012	177.62	179.33	1.9473	.26683	.9566	.64292
480.00	1.6868	183.47	185.24	2.0057	.27467	.9560	.65471
490.00	1.6730	189.36	191.19	2.0644	.28287	.9555	.66622

TIN

PROTON ENERGY MEV	ENERGY LOSS MEV/CH	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PATH LENGTH STRAGGLING GM/CH2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.6598	195.30	26.761	2.1233	.29095	1.077	.67746
510.00	1.6471	201.29	27.582	2.1826	.29907	1.074	.68843
520.00	1.6350	207.33	28.409	2.2422	.30723	1.071	.69912
530.00	1.6234	213.41	29.242	2.3020	.31543	1.068	.70954
540.00	1.6122	219.53	30.081	2.3621	.32366	1.066	.71968
550.00	1.6015	225.69	30.925	2.4225	.33193	1.063	.72955
560.00	1.5912	231.90	31.775	2.4831	.34024	1.061	.73916
570.00	1.5813	238.14	32.631	2.5439	.34857	1.058	.74849
580.00	1.5717	244.42	33.492	2.6050	.35694	1.056	.75757
590.00	1.5625	250.74	34.358	2.6663	.36534	1.053	.76638
600.00	1.5537	257.10	35.228	2.7278	.37377	1.051	.77494
620.00	1.5370	269.92	36.935	2.8514	.39071	1.046	.79130
640.00	1.5215	282.96	38.772	2.9759	.40776	1.042	.80667
660.00	1.5070	296.04	40.565	3.1010	.42492	1.038	.82110
680.00	1.4935	309.25	42.375	3.2269	.44216	1.034	.83462
700.00	1.4810	322.58	44.201	3.3534	.45950	1.030	.84727
720.00	1.4692	336.02	46.042	3.4806	.47692	1.026	.85908
740.00	1.4582	349.55	47.897	3.6083	.49442	1.023	.87010
760.00	1.4475	363.19	49.766	3.7366	.51200	1.019	.88036
780.00	1.4382	376.93	51.648	3.8654	.52965	1.016	.88991
800.00	1.4292	390.75	53.542	3.9947	.54736	1.013	.89877
820.00	1.4207	404.65	55.448	4.1244	.56514	1.010	.90701
840.00	1.4126	418.65	57.366	4.2546	.58298	1.007	.91464
860.00	1.4051	432.72	59.293	4.3852	.60088	1.004	.92170
880.00	1.3980	446.87	61.231	4.5162	.61883	1.001	.92823
900.00	1.3913	461.08	63.179	4.6476	.63683	.9986	.93427
920.00	1.3850	475.48	65.151	4.7793	.65488	.9958	.93984
940.00	1.3791	489.84	67.120	4.9114	.67298	.9933	.94498
960.00	1.3735	504.34	69.106	5.0438	.69112	.9908	.94971
1000.00	1.3632	533.58	73.113	5.3096	.72754	.9859	.95802

THE ELECTRON DENSITY OF TIN IS 2.538E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.005 BEV, AND THE MINIMUM ENERGY LOSS IS 1.2861 MEV/GM/CH2

# TITANIUM

ELEMENT Ti  
ATOMIC NUMBER 22  
ATOMS/MOLECULE 1  
ATOMIC WEIGHT 47.900  
ADJUSTED IONIZATION POTENTIAL 227.2

DENSITY = 4.5400 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	MEV/GM/CM2	MEV/CM	MG/CM2	MM	MG/CM2	MM	MG/CM2	MM			
.10	447.51	2031.7	.40676	.00090	.41494	.00091	.01743	.00004	4.201	1.967	0.
.15	403.75	1833.0	.52396	.00115	.53252	.00117	.01919	.00004	3.603	1.606	0.
.20	367.00	1666.2	.65298	.00144	.66237	.00146	.02124	.00005	3.207	1.417	0.
.30	305.67	1387.7	.94961	.00209	.96126	.00212	.02689	.00006	2.797	1.212	0.
.40	258.00	1171.3	1.3036	.00287	1.3181	.00290	.03492	.00008	2.649	1.098	0.
.50	224.58	1019.6	1.7169	.00378	1.7346	.00382	.04490	.00010	2.580	1.024	0.
.60	201.78	916.08	2.1637	.00481	2.2051	.00486	.05616	.00012	2.547	.9718	0.
.70	182.49	828.52	2.7007	.00595	2.7261	.00600	.06840	.00015	2.509	.9329	0.
.80	168.11	763.22	3.2703	.00720	3.3000	.00727	.08172	.00018	2.476	.9023	0.
.90	154.73	702.49	3.8950	.00856	3.9194	.00863	.09576	.00021	2.443	.8775	0.
1.00	141.35	641.72	4.5564	.01004	4.5958	.01012	.11116	.00024	2.419	.8567	0.
1.20	126.43	573.99	6.0438	.01331	6.0941	.01342	.14452	.00032	2.371	.8245	0.
1.40	114.96	521.91	7.6932	.01695	7.7553	.01708	.17952	.00040	2.315	.8003	0.
1.60	105.86	480.60	9.4963	.02092	9.5711	.02108	.21613	.00048	2.258	.7810	0.
1.80	98.345	446.48	11.446	.02521	11.534	.02540	.25434	.00056	2.205	.7646	0.
2.00	92.006	417.71	13.535	.02981	13.637	.03004	.29415	.00065	2.157	.7505	0.
2.20	86.542	392.90	15.762	.03472	15.879	.03498	.33558	.00074	2.113	.7381	0.
2.40	81.773	371.25	18.125	.03992	18.258	.04022	.37876	.00083	2.075	.7269	0.
2.60	77.563	352.14	20.622	.04542	20.771	.04575	.42413	.00093	2.042	.7160	0.
2.80	73.814	335.11	23.249	.05121	23.415	.05157	.47162	.00104	2.014	.7076	0.
3.00	70.452	319.85	26.005	.05728	26.188	.05760	.52115	.00115	1.990	.6991	0.
3.20	67.415	306.06	28.890	.06363	29.091	.06408	.57262	.00126	1.968	.6912	.00001
3.40	64.669	293.60	31.902	.07027	32.121	.07075	.62596	.00138	1.949	.6839	.00001
3.60	62.160	282.24	35.039	.07718	35.278	.07770	.68110	.00150	1.931	.6772	.00001
3.80	59.882	271.87	38.297	.08436	38.556	.08492	.73798	.00163	1.914	.6708	.00002
4.00	57.782	262.33	41.677	.09180	41.956	.09241	.79655	.00175	1.899	.6649	.00002
4.20	55.845	253.54	45.179	.09951	45.478	.10017	.85675	.00189	1.884	.6593	.00003
4.40	54.048	245.38	48.797	.10748	49.119	.10819	.91858	.00202	1.870	.6541	.00004
4.60	52.374	237.78	52.535	.11572	52.878	.11647	.98200	.00216	1.857	.6491	.00004
4.80	50.808	230.67	56.390	.12421	56.756	.12501	1.0470	.00231	1.845	.6444	.00005

# TITANIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE CM	PROTON PATH LENGTH CM	GM/CM2	GM/CM2	PATH LENGTH STRAGGLING CM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	49.342	224.01	.06036	.01330	.00111	.00025	1.833	.6399	.00006
5.50	46.098	209.28	.07079	.01559	.00129	.00028	1.806	.6297	.00009
6.00	43.280	196.49	.08194	.01805	.00147	.00032	1.782	.6206	.00012
6.50	40.863	185.52	.09377	.02065	.00166	.00037	1.760	.6125	.00016
7.00	38.727	175.82	.10627	.02341	.00186	.00041	1.739	.6051	.00021
7.50	36.827	167.20	.11945	.02631	.00207	.00046	1.721	.5984	.00027
8.00	35.126	159.47	.13327	.02935	.00228	.00050	1.703	.5923	.00034
8.50	33.593	152.51	.14776	.03255	.00251	.00055	1.687	.5867	.00041
9.00	32.202	146.20	.16289	.03588	.00274	.00060	1.672	.5815	.00049
9.50	30.933	140.44	.17865	.03935	.00298	.00066	1.658	.5767	.00058
10.00	29.772	135.16	.19504	.04296	.00323	.00071	1.645	.5722	.00068
11.00	27.718	125.84	.22970	.05059	.00375	.00083	1.622	.5641	.00090
12.00	25.958	117.85	.26681	.05877	.00429	.00095	1.601	.5570	.00126
13.00	24.430	110.91	.30634	.06748	.00487	.00107	1.582	.5506	.00168
14.00	23.092	104.04	.34825	.07671	.00548	.00121	1.565	.5450	.00211
15.00	21.909	99.425	.39250	.08645	.00611	.00135	1.549	.5398	.00255
16.00	20.854	94.677	.43907	.09671	.00678	.00149	1.535	.5351	.00301
17.00	19.908	90.381	.48793	.10747	.00747	.00164	1.522	.5309	.00349
18.00	19.053	86.503	.53903	.11873	.00818	.00180	1.510	.5270	.00397
19.00	18.278	82.992	.59237	.13048	.00893	.00197	1.499	.5234	.00443
20.00	17.571	79.771	.64792	.14271	.00969	.00214	1.489	.5200	.00487
22.00	16.326	74.122	.76553	.16852	.01131	.00249	1.470	.5140	.00581
24.00	15.265	69.304	.89169	.19641	.01302	.00287	1.453	.5080	.00682
26.00	14.350	65.150	1.0263	.22605	.01483	.00327	1.438	.5042	.00787
28.00	13.552	61.524	1.1691	.25751	.01673	.00359	1.424	.5001	.00888
30.00	12.848	58.329	1.3200	.29075	.01873	.00413	1.412	.4964	.00985
32.00	12.223	55.491	1.4789	.32575	.02081	.00458	1.400	.4930	.01073
34.00	11.663	52.952	1.6457	.36249	.02299	.00506	1.390	.4900	.01150
36.00	11.160	50.665	1.8203	.40094	.02525	.00556	1.380	.4872	.01227
38.00	10.704	48.599	2.0024	.44107	.02759	.00606	1.371	.4847	.01299
40.00	10.289	46.711	2.1922	.48286	.03032	.00661	1.363	.4823	.01363
45.00	8.3976	42.665	2.7119	.59734	.03644	.00803	1.344	.4772	.01502
50.00	8.6685	39.355	3.2510	.71609	.04335	.00955	1.327	.4728	.01643
55.00	8.0603	36.594	3.8476	.84736	.05074	.01118	1.313	.4691	.01781
60.00	7.5441	34.250	4.4858	.98806	.05857	.01290	1.300	.4659	.01920
65.00	7.1015	32.241	5.1663	1.1379	.06685	.01472	1.288	.4631	.02063
70.00	6.7170	30.495	5.8874	1.2968	.07554	.01664	1.277	.4607	.02211
75.00	6.3793	28.962	6.6481	1.4643	.08464	.01864	1.267	.4585	.02361
80.00	6.0807	27.606	7.4477	1.6405	.09414	.02074	1.258	.4565	.02519
90.00	5.5757	25.314	9.1597	2.0176	.11426	.02517	1.242	.4531	.03170

# TITANIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CH	PROTON RANGE GH/CH2	PROTON PATH LENGTH GH/CH2	PATH LENGTH STRAGGLING GH/CH2	CH PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	5.1647	23.448	11.017	2.4267	11.067	2.4376	.13582
110.00	4.3234	21.898	13.013	2.8664	13.072	2.8793	.15873
120.00	4.5354	20.591	15.144	3.3356	15.211	3.3505	.18293
130.00	4.2889	19.472	17.403	3.8332	17.480	3.8502	.20832
140.00	4.0757	18.503	19.785	4.3580	19.873	4.3774	.23488
150.00	3.8892	17.657	22.287	4.9091	22.386	4.9308	.26252
160.00	3.7249	16.911	24.904	5.4855	25.014	5.5097	.29119
170.00	3.5789	16.248	27.632	6.0864	27.754	6.1132	.32085
180.00	3.4484	15.656	30.467	6.7109	30.601	6.7404	.35245
190.00	3.3310	15.123	33.406	7.3582	33.553	7.3904	.38293
200.00	3.2249	14.641	36.445	8.0275	36.604	8.0626	.41528
210.00	3.1285	14.203	39.580	8.7121	39.753	8.7562	.44843
220.00	3.0405	13.804	42.809	9.4294	42.996	9.4705	.48236
230.00	2.9600	13.438	46.129	10.161	46.330	10.205	.51703
240.00	2.8860	13.102	49.537	10.911	49.752	10.959	.55242
250.00	2.8177	12.792	53.029	11.680	53.259	11.731	.58848
260.00	2.7545	12.506	56.604	12.468	56.849	12.522	.62519
270.00	2.6960	12.240	60.258	13.273	60.519	13.330	.66252
280.00	2.6415	11.993	63.990	14.095	64.267	14.156	.70046
290.00	2.5908	11.762	67.797	14.933	68.090	14.998	.73896
300.00	2.5434	11.547	71.676	15.788	71.986	15.856	.77802
310.00	2.4991	11.346	75.626	16.652	75.953	16.730	.81760
320.00	2.4575	11.157	79.645	17.543	79.988	17.619	.85769
330.00	2.4184	10.979	83.730	18.443	84.090	18.523	.89826
340.00	2.3816	10.813	87.879	19.357	88.257	19.441	.93930
350.00	2.3470	10.655	92.092	20.285	92.487	20.371	.98079
360.00	2.3142	10.507	96.365	21.226	96.779	21.317	1.0227
370.00	2.2833	10.366	100.70	22.180	101.13	22.275	1.0651
380.00	2.2541	10.233	105.09	23.147	105.54	23.246	1.1078
390.00	2.2263	10.107	109.53	24.126	110.00	24.229	1.1509
400.00	2.2000	9.9880	114.03	25.117	114.52	25.225	1.1944
410.00	2.1750	9.8745	118.58	26.120	119.09	26.232	1.2383
420.00	2.1512	9.7666	123.19	27.134	123.72	27.250	1.2825
430.00	2.1286	9.6639	127.84	28.159	128.39	28.279	1.3270
440.00	2.1071	9.5661	132.54	29.195	133.11	29.320	1.3719
450.00	2.0865	9.4728	137.29	30.241	137.88	30.370	1.4170
460.00	2.0669	9.3837	142.09	31.297	142.70	31.431	1.4625
470.00	2.0482	9.2986	146.93	32.364	147.56	32.501	1.5082
480.00	2.0302	9.2173	151.81	33.439	152.46	33.582	1.5543
490.00	2.0131	9.1394	156.74	34.524	157.41	34.671	1.6006
							.28671
							.30372
							.32073
							.33770
							.35459
							.37137
							.38804
							.40464
							.42112
							.43746
							.45364
							.46982
							.48538
							.50090
							.51617
							.53116
							.54593
							.56050
							.57485
							.58899
							.60288
							.61650
							.62979
							.64276
							.65541
							.66773
							.67922
							.69139
							.70373
							.71575

# TITANIUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	MEV/ GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM			
500.00	1.9967	9.0649	161.71	35.618	162.39	35.770	1.6471	.36281	1.014	.4231	.72445
510.00	1.9810	8.9935	166.72	36.721	167.42	36.877	1.6940	.37312	1.012	.4228	.73483
520.00	1.9659	8.9251	171.76	37.833	172.49	37.994	1.7410	.38348	1.009	.4225	.74490
530.00	1.9514	8.8594	176.85	38.953	177.60	39.118	1.7883	.39390	1.007	.4222	.75466
540.00	1.9375	8.7964	181.97	40.081	182.74	40.251	1.8358	.40437	1.005	.4219	.76411
550.00	1.9242	8.7358	187.13	41.217	187.92	41.392	1.8836	.41488	1.002	.4216	.77327
560.00	1.9114	8.6776	192.32	42.361	193.13	42.540	1.9315	.42545	1.000	.4213	.78212
570.00	1.8990	8.6217	197.55	43.512	198.38	43.696	1.9797	.43605	.9979	.4210	.79069
580.00	1.8872	8.5678	202.81	44.671	203.66	44.860	2.0281	.44671	.9958	.4207	.79897
590.00	1.8758	8.5160	208.10	45.837	208.98	46.031	2.0766	.45740	.9937	.4204	.80698
600.00	1.8648	8.4661	213.43	47.010	214.33	47.208	2.1254	.46814	.9916	.4201	.81471
620.00	1.8440	8.3716	224.17	49.376	225.11	49.584	2.2234	.48974	.9877	.4196	.82938
640.00	1.8246	8.2838	235.03	51.768	236.02	51.986	2.3221	.51148	.9839	.4190	.84303
660.00	1.8066	8.2020	246.00	54.185	247.03	54.413	2.4215	.53337	.9802	.4184	.85571
680.00	1.7898	8.1257	257.08	56.625	258.16	56.863	2.5215	.55540	.9767	.4178	.86748
700.00	1.7741	8.0543	268.26	59.087	269.38	59.335	2.6221	.57755	.9734	.4172	.87839
720.00	1.7594	7.9876	279.53	61.571	280.70	61.829	2.7232	.59983	.9701	.4166	.88848
740.00	1.7456	7.9252	290.90	64.075	292.11	64.342	2.8249	.62222	.9670	.4160	.89701
760.00	1.7327	7.8666	302.35	66.598	303.62	66.876	2.9270	.64471	.9640	.4154	.90642
780.00	1.7206	7.8116	313.89	69.139	315.20	69.427	3.0296	.66731	.9612	.4148	.91437
800.00	1.7092	7.7599	325.51	71.698	326.86	71.996	3.1326	.69001	.9584	.4142	.92168
820.00	1.6985	7.7113	337.20	74.273	338.60	74.582	3.2361	.71280	.9557	.4136	.92842
840.00	1.6885	7.6656	348.97	76.865	350.41	77.184	3.3400	.73568	.9532	.4130	.93461
860.00	1.6790	7.6225	360.80	79.471	362.29	79.801	3.4443	.75865	.9507	.4124	.94030
880.00	1.6700	7.5819	372.70	82.093	374.24	82.432	3.5489	.78169	.9483	.4118	.94553
900.00	1.6616	7.5436	384.67	84.728	386.25	85.078	3.6539	.80482	.9460	.4112	.95032
920.00	1.6536	7.5074	396.69	87.378	398.33	87.738	3.7592	.82801	.9437	.4106	.95471
940.00	1.6461	7.4732	408.78	90.041	410.47	90.411	3.8648	.85128	.9416	.4099	.95973
960.00	1.6390	7.4409	420.94	92.718	422.67	93.099	3.9707	.87461	.9394	.4091	.96241
1000.00	1.6259	7.3815	445.53	98.135	447.35	98.536	4.1835	.92148	.9352	.4070	.96885

THE ELECTRON DENSITY OF TITANIUM IS 2.767E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.129 BEV, AND THE MINIMUM ENERGY LOSS IS 1.5206 MEV/GM/CM2

TUNGSTEN

ELEMENT NUMBER 74  
 ATOMIC WEIGHT 183.85  
 ADJUSTED IONIZATION POTENTIAL 731.8  
 ATOMS/MOLECULE 1

DENSITY = 19.300 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS GM/CM2	PROTON RANGE MG/CM2	PROTON PATH LENGTH HG/CM2	PATH LENGTH STRAGGLING HG/CM2	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	MULTIPLE SCATTERING PERCENT	PATH LENGTH PERCENT
.10	119.53	2307.0	1.1775	.00061	.06261	.00003	5.029
.15	123.03	2374.5	1.5847	.00082	.07733	.00004	4.086
.20	121.96	2353.9	1.9620	.00103	.09117	.00005	3.798
.30	112.28	2167.1	2.8055	.00145	.11874	.00006	3.648
.40	99.622	1922.7	3.7175	.00193	.14882	.00008	3.610
.50	88.808	1714.0	4.7448	.00246	.18302	.00009	3.589
.60	81.304	1569.2	5.8828	.00305	.22045	.00011	3.569
.70	75.924	1465.3	7.1123	.00369	.25929	.00013	3.548
.80	69.366	1337.6	8.4391	.00437	.30036	.00016	3.524
.90	68.852	1328.8	9.8370	.00510	.34155	.00018	3.498
1.00	68.396	1320.1	11.248	.00583	.37843	.00020	3.470
1.20	63.217	1220.1	14.195	.00736	.45188	.00023	3.405
1.40	58.827	1135.4	17.378	.00900	.53235	.00028	3.336
1.60	55.116	1063.7	20.792	.01077	.61834	.00032	3.267
1.80	51.919	1002.0	24.428	.01266	.70884	.00037	3.200
2.00	49.127	948.14	28.281	.01465	.80333	.00042	3.137
2.20	46.664	900.61	32.348	.01725	.90147	.00047	3.078
2.40	44.475	858.36	36.626	.01998	1.0031	.00052	3.023
2.60	42.517	820.58	41.110	.02130	1.1079	.00057	2.971
2.80	40.755	786.58	45.795	.02373	1.2158	.00063	2.924
3.00	39.443	761.24	50.679	.02626	1.3265	.00069	2.879
3.20	37.955	732.53	55.702	.02886	1.4381	.00075	2.838
3.40	36.592	706.23	60.973	.03159	1.5528	.00080	2.799
3.60	35.339	682.04	66.397	.03440	1.6706	.00087	2.763
3.80	34.191	659.89	72.003	.03731	1.7913	.00093	2.730
4.00	33.105	638.93	77.807	.04031	1.9151	.00099	2.697
4.20	32.138	620.26	83.829	.04343	2.0414	.00106	2.667
4.40	31.234	602.81	89.980	.04662	2.1702	.00112	2.637
4.60	30.388	586.48	96.331	.04991	2.3015	.00119	2.610
4.80	29.594	571.16	102.86	.05330	2.4351	.00126	2.585

TUNGSTEN

PROTON ENERGY MEV	ENERGY LOSS MEV/CM GM/CM2	PROTON RANGE GM/CM2 CM	PROTON PATH LENGTH GM/CM2 CM	PATH LENGTH STRAGGLING GM/CM2 CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	28.848	10958	11246	.00257	2.560	0.
5.50	27.105	12704	.00583	.00013	2.504	0.
6.00	25.700	14358	.00675	.00015	2.455	0.
6.50	24.410	16515	.00773	.00017	2.411	.00002
7.00	23.268	18569	.00877	.00019	2.371	.00005
7.50	22.242	20725	.00986	.00021	2.335	.00007
8.00	21.331	22974	.01100	.00023	2.302	.00009
8.50	20.504	25321	.01218	.00026	2.272	.00010
9.00	19.750	27757	.01342	.00028	2.245	.00010
9.50	19.057	30283	.01471	.00030	2.219	.00010
			.01605	.00033		
10.00	18.423	32904	.01743	.00035	2.195	.00011
11.00	17.292	38401	.02033	.00041	2.152	.00013
12.00	16.312	44248	.02342	.00046	2.115	.00016
13.00	15.454	50433	.02669	.00052	2.081	.00021
14.00	14.695	56951	.03013	.00058	2.051	.00028
15.00	14.018	63796	.03374	.00064	2.025	.00037
16.00	13.410	70964	.03752	.00070	2.000	.00048
17.00	12.861	78446	.04147	.00077	1.978	.00062
18.00	12.362	86239	.04558	.00084	1.957	.00077
19.00	11.906	94341	.04985	.00091	1.938	.00095
			.05428			
20.00	11.488	10275	1.0476	.00098	1.921	.00116
22.00	10.746	12045	1.2277	.00113	1.889	.00163
24.00	10.109	13933	1.4197	.00128	1.862	.00219
26.00	9.5759	15936	1.6234	.00145	1.837	.00316
28.00	9.0882	18042	1.8376	.00162	1.816	.00456
30.00	8.6552	20266	2.0636	.00179	1.796	.00601
32.00	8.2681	22591	2.3000	.00198	1.779	.00751
34.00	7.9184	25022	2.5471	.00217	1.763	.00907
36.00	7.6038	27562	2.8053	.00236	1.748	.01068
38.00	7.3166	30199	3.0732	.00257	1.735	.01234
			.17066			
40.00	7.0547	32938	3.3515	.00278	1.722	.01405
45.00	6.4871	40222	4.0915	.00333	1.694	.01849
50.00	6.0176	48108	4.8926	.00392	1.671	.02318
55.00	5.6222	56580	5.7530	.00455	1.651	.02810
60.00	5.2847	65617	6.6707	.00521	1.634	.03328
65.00	4.9930	75186	7.6423	.00590	1.620	.03868
70.00	4.7380	85312	8.6705	.00663	1.606	.04429
75.00	4.5127	95970	9.7525	.00738	1.594	.05009
80.00	4.3130	10713	10.886	.00817	1.584	.05606
90.00	3.9734	13094	13.303	.00982	1.566	.06848
			.67846			



TUNGSTEN

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH GM/CM <sup>2</sup>	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM <sup>2</sup>	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	3.6962	71.337	15.567	81174	15.913	82452	.22349	.08140
110.00	3.4645	66.864	18.422	95491	18.710	96942	.25930	.09482
120.00	3.2679	63.071	21.352	11063	21.684	11235	.29690	.10876
130.00	3.0990	59.811	24.428	12667	24.825	12863	.33617	.12312
140.00	2.9523	56.979	27.707	14356	28.132	14576	.37704	.13785
150.00	2.8236	54.495	31.122	16125	31.597	16371	.41941	.15288
160.00	2.7098	52.298	34.685	17972	35.212	18245	.46321	.16820
170.00	2.6084	50.342	38.393	19893	38.974	20194	.50837	.18383
180.00	2.5176	48.590	42.241	21886	42.878	22216	.55481	.19971
190.00	2.4357	47.010	46.221	23949	46.916	24309	.60248	.21579
200.00	2.3616	45.579	50.329	26077	51.083	26468	.65131	.23203
210.00	2.2963	44.318	54.559	28269	55.375	28692	.70114	.24835
220.00	2.2344	43.125	58.915	30526	59.794	30981	.75200	.26470
230.00	2.1777	42.030	63.387	32843	64.330	33332	.80389	.28104
240.00	2.1256	41.024	67.960	35212	68.970	35736	.85675	.29734
250.00	2.0774	40.095	72.655	37645	73.732	38203	.91054	.31356
260.00	2.0329	39.234	77.455	40132	78.601	40726	.96520	.32968
270.00	1.9915	38.436	82.357	42672	83.574	43303	1.0207	.34565
280.00	1.9530	37.693	87.358	45263	88.647	45931	1.0770	.36146
290.00	1.9173	37.000	92.439	47896	93.801	48602	1.1341	.37709
300.00	1.8836	36.353	97.529	50585	99.066	51330	1.1919	.39251
310.00	1.8512	35.729	102.91	53321	104.42	54105	1.2506	.40779
320.00	1.8217	35.160	108.28	56105	109.87	56929	1.3099	.42297
330.00	1.7941	34.625	113.74	58931	115.40	59795	1.3698	.43804
340.00	1.7680	34.122	119.27	61798	121.02	62704	1.4303	.45298
350.00	1.7434	33.648	124.89	64708	126.71	65655	1.4915	.46776
360.00	1.7202	33.200	130.62	67681	132.53	68671	1.5532	.48239
370.00	1.6983	32.777	136.39	70670	138.39	71703	1.6155	.49686
380.00	1.6775	32.376	142.20	73680	144.28	74756	1.6782	.51116
390.00	1.6578	31.996	148.10	76736	150.26	77855	1.7415	.52526
400.00	1.6392	31.636	154.08	79834	156.33	80998	1.8053	.53918
410.00	1.6214	31.294	160.13	82967	162.46	84175	1.8695	.55287
420.00	1.6046	30.968	165.24	86133	168.65	87386	1.9342	.56631
430.00	1.5885	30.658	172.41	89332	174.92	90631	1.9993	.57951
440.00	1.5732	30.361	178.65	92563	181.24	93908	2.0648	.59245
450.00	1.5586	30.081	184.94	95824	187.63	97216	2.1308	.60513
460.00	1.5447	29.813	191.29	99116	194.07	100595	2.1971	.61755
470.00	1.5314	29.556	197.70	10244	200.57	10392	2.2637	.62971
480.00	1.5187	29.311	204.17	10579	207.13	10732	2.3308	.64159
490.00	1.5065	29.076	210.68	10916	213.74	11074	2.3981	.65321

TUNGSTEN

PROCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	MEV/ GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM			
500.00	1.4949	28.851	217.25	11.257	220.43	11.420	2.4658	.12776	1.119	1.427	.66456
510.00	1.4837	28.636	223.90	11.601	227.14	11.769	2.5338	.13129	1.116	1.426	.67563
520.00	1.4730	28.430	230.57	11.947	233.90	12.119	2.6022	.13483	1.112	1.425	.68644
530.00	1.4628	28.232	237.29	12.295	240.71	12.472	2.6708	.13838	1.110	1.424	.69697
540.00	1.4530	28.042	244.05	12.645	247.57	12.828	2.7397	.14195	1.107	1.423	.70724
550.00	1.4435	27.860	250.86	12.998	254.48	13.185	2.8089	.14554	1.104	1.422	.71724
560.00	1.4344	27.685	257.71	13.353	261.43	13.545	2.8783	.14913	1.101	1.422	.72698
570.00	1.4257	27.516	264.61	13.710	268.42	13.908	2.9480	.15275	1.098	1.421	.73645
580.00	1.4173	27.355	271.34	14.070	275.45	14.272	3.0179	.15637	1.096	1.420	.74567
590.00	1.4093	27.199	278.52	14.431	282.53	14.639	3.0881	.16001	1.093	1.419	.75463
600.00	1.4015	27.049	285.54	14.795	289.64	15.008	3.1585	.16365	1.090	1.418	.76333
620.00	1.3868	26.765	299.68	15.528	303.99	15.751	3.3000	.17099	1.086	1.417	.77999
640.00	1.3732	26.502	313.97	16.268	318.48	16.502	3.4423	.17836	1.081	1.415	.79568
660.00	1.3605	26.257	328.40	17.016	333.11	17.260	3.5854	.18577	1.076	1.414	.81044
680.00	1.3486	26.029	342.96	17.770	347.88	18.025	3.7293	.19323	1.072	1.413	.82429
700.00	1.3376	25.816	357.65	18.531	362.77	18.796	3.8738	.20072	1.068	1.411	.83727
720.00	1.3273	25.616	372.49	19.300	377.82	19.576	4.0190	.20824	1.064	1.410	.84943
740.00	1.3176	25.430	387.54	20.080	393.07	20.366	4.1648	.21579	1.060	1.407	.86079
760.00	1.3086	25.256	402.57	20.859	408.31	21.156	4.3111	.22337	1.056	1.406	.87140
780.00	1.3001	25.093	417.70	21.643	423.65	21.951	4.4580	.23099	1.052	1.404	.88130
800.00	1.2922	24.940	432.93	22.431	439.09	22.751	4.6054	.23862	1.049	1.404	.89052
820.00	1.2848	24.796	448.25	23.225	454.62	23.556	4.7533	.24629	1.046	1.402	.89910
840.00	1.2778	24.661	463.65	24.024	470.24	24.365	4.9016	.25397	1.042	1.401	.90707
860.00	1.2712	24.534	479.15	24.826	485.95	25.179	5.0504	.26168	1.039	1.399	.91447
880.00	1.2650	24.415	494.72	25.633	501.73	25.997	5.1996	.26941	1.036	1.398	.92134
900.00	1.2592	24.302	510.37	26.444	517.60	26.818	5.3491	.27716	1.033	1.396	.92770
920.00	1.2537	24.197	526.10	27.259	533.54	27.645	5.4991	.28493	1.031	1.395	.93359
940.00	1.2485	24.097	541.81	28.078	549.56	28.475	5.6493	.29271	1.028	1.392	.93904
960.00	1.2437	24.003	557.80	28.902	565.67	29.302	5.7999	.30051	1.025	1.390	.94407
1000.00	1.2348	23.831	589.97	30.568	598.24	30.997	6.1021	.31617	1.020	1.384	.95297

THE ELECTRON DENSITY OF TUNGSTEN IS 2.425E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.934 BEV, AND THE MINIMUM ENERGY LOSS IS 1.1695 MEV/GM/CM2

# URANIUM

ELEMENT U  
 ATOMIC NUMBER 92  
 ATOMS/MOLECULE 1  
 ATOMIC WEIGHT 238.03  
 ADJUSTED IONIZATION POTENTIAL 908.0

DENSITY = 18.700 GM/CM<sup>3</sup>

PRCTCN ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/CM	MEV/CH	MG/CM <sup>2</sup>	MM	MG/CM <sup>2</sup>	MM	MG/CM <sup>2</sup>	MM		
.10	120.02	2244.5	1.4346	.00077	1.5254	.00082	.07936	.00004	5.202	0.
.15	125.55	2347.8	1.8375	.00098	1.9327	.00103	.09064	.00005	4.690	0.
.20	124.17	2322.0	2.282	.00119	2.3331	.00125	.10079	.00005	4.320	0.
.30	111.44	2083.9	3.0483	.00163	3.1800	.00170	.12173	.00007	3.828	0.
.40	98.267	1837.6	3.9719	.00212	4.1371	.00221	.14658	.00008	3.543	0.
.50	88.919	1662.8	5.0047	.00268	5.2085	.00279	.17735	.00009	3.405	0.
.60	81.361	1521.4	6.1383	.00328	6.3847	.00341	.21352	.00011	3.344	0.
.70	75.888	1419.1	7.3648	.00394	7.6572	.00409	.25303	.00014	3.305	0.
.80	69.899	1307.1	8.6887	.00465	9.0302	.00483	.29577	.00016	3.275	0.
.90	65.969	1233.6	10.106	.00541	10.502	.00562	.34134	.00018	3.250	0.
1.00	62.030	1160.0	11.617	.00621	12.066	.00645	.38884	.00021	3.223	0.
1.20	56.354	1053.8	14.867	.00796	15.454	.00826	.48895	.00026	3.164	0.
1.40	51.883	970.21	18.464	.00987	19.156	.01024	.59347	.00032	3.098	0.
1.60	48.243	902.15	22.333	.01194	23.159	.01238	.70204	.00038	3.031	0.
1.80	45.215	845.53	26.479	.01416	27.446	.01468	.81435	.00044	2.967	0.
2.00	42.649	797.54	30.888	.01652	32.002	.01711	.93016	.00050	2.907	0.
2.20	40.437	756.17	35.552	.01901	36.819	.01969	1.0503	.00056	2.853	0.
2.40	38.497	719.89	40.466	.02164	41.891	.02240	1.1769	.00063	2.809	0.
2.60	36.792	688.01	45.618	.02439	47.208	.02524	1.3091	.00070	2.773	0.
2.80	35.271	659.56	51.001	.02727	52.761	.02821	1.4461	.00077	2.741	0.
3.00	33.899	633.91	56.612	.03027	58.546	.03131	1.5873	.00085	2.711	0.
3.20	32.654	610.63	62.445	.03339	64.558	.03452	1.7325	.00093	2.684	0.
3.40	31.516	589.36	68.495	.03663	70.792	.03786	1.8814	.00101	2.658	0.
3.60	30.476	569.91	74.764	.03998	77.249	.04131	2.0337	.00109	2.633	0.
3.80	29.519	552.01	81.240	.04344	83.919	.04488	2.1893	.00117	2.609	0.
4.00	28.635	535.47	87.922	.04702	90.798	.04856	2.3480	.00126	2.586	0.
4.20	27.816	520.15	94.809	.05070	97.886	.05235	2.5086	.00134	2.564	0.
4.40	27.054	505.91	101.90	.05449	105.18	.05624	2.6741	.00143	2.542	0.
4.60	26.343	492.61	109.18	.05838	112.67	.06025	2.8414	.00152	2.522	0.
4.80	25.707	480.73	116.45	.06236	120.35	.06436	3.0108	.00161	2.502	0.

URANIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	25.078	468.95	.12430	.00665	.00686	.00318	0.
5.50	23.657	442.39	.14877	.00772	.00819	.00362	0.
6.00	22.411	419.09	.16546	.00885	.00912	.00408	0.
6.50	21.345	399.16	.18773	.01004	.01034	.00455	0.
7.00	20.391	381.32	.21106	.01129	.01162	.00504	0.
7.50	19.533	365.26	.23549	.01259	.01296	.00554	0.
8.00	18.756	350.73	.26093	.01395	.01436	.00605	0.
8.50	18.049	337.52	.28745	.01537	.01581	.00658	0.
9.00	17.403	325.44	.31497	.01684	.01732	.00712	0.
9.50	16.810	314.34	.34349	.01837	.01889	.00767	0.
10.00	16.262	304.10	.37297	.01995	.02050	.00824	0.
11.00	15.284	285.81	.43493	.02326	.02390	.00942	.00001
12.00	14.433	269.90	.50075	.02678	.02750	.01067	.00002
13.00	13.699	256.18	.57023	.03049	.03131	.01198	.00004
14.00	13.046	243.96	.64329	.03440	.03531	.01333	.00007
15.00	12.465	233.09	.71992	.03850	.03950	.01474	.00012
16.00	11.942	223.31	.80005	.04278	.04389	.01619	.00019
17.00	11.463	214.36	.88363	.04725	.04846	.01768	.00028
18.00	11.035	206.36	.97057	.05190	.05321	.01922	.00039
19.00	10.643	199.03	1.0608	.05673	.05815	.02081	.00052
20.00	10.283	192.29	1.1544	.06173	.06326	.02243	.00067
22.00	9.6402	180.27	1.3510	.07235	.07401	.02581	.00104
24.00	9.0868	169.92	1.5602	.08343	.08545	.02933	.00150
26.00	8.6418	161.60	1.7818	.09528	.09755	.03301	.00241
28.00	8.2087	153.50	2.0138	.10769	.11022	.03679	.00379
30.00	7.8235	146.30	2.2592	.12081	.12362	.04073	.00522
32.00	7.4796	139.87	2.5150	.13449	.13759	.04481	.00671
34.00	7.1698	134.07	2.7822	.14878	.15218	.04903	.00824
36.00	6.8890	128.82	3.0608	.16368	.16738	.05340	.00983
38.00	6.6331	124.04	3.3515	.17922	.18324	.05790	.01147
40.00	6.3991	119.66	3.6519	.19529	.19964	.06253	.01314
45.00	5.8919	110.18	4.4515	.23805	.24326	.07467	.01753
50.00	5.4751	102.38	5.3155	.28425	.29039	.08756	.02214
55.00	5.1347	96.018	6.2407	.33373	.34084	.10109	.02699
60.00	4.8324	90.366	7.2258	.38641	.39455	.11531	.03267
65.00	4.5702	85.462	8.2689	.44219	.45141	.13035	.03738
70.00	4.3412	81.180	9.3708	.50111	.51147	.14588	.04290
75.00	4.1389	77.397	10.530	.56310	.57465	.16217	.04860
80.00	3.9588	74.029	11.741	.62786	.64065	.17908	.05448
90.00	3.6518	68.288	14.326	.76608	.78148	.21470	.06672

URANIUM

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH CM		GM/CM2	PATH LENGTH STRAGGLING CM		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
			GM/CM2	CM		GM/CM2	CM		
100.00	3.3998	17.115	17.455	.93344	.25256	.01351	1.447	1.951	.07948
110.00	3.1890	20.097	20.493	1.0959	.29251	.01564	1.427	1.934	.09275
120.00	3.0098	23.256	23.711	1.2680	.33444	.01788	1.410	1.919	.10655
130.00	2.8553	26.605	27.122	1.4504	.37823	.02023	1.395	1.906	.12079
140.00	2.7220	30.126	30.708	1.6421	.42376	.02266	1.380	1.895	.13540
150.00	2.6050	33.815	34.465	1.8431	.47091	.02518	1.366	1.885	.15032
160.00	2.5013	37.663	38.383	2.0526	.51960	.02779	1.354	1.877	.16550
170.00	2.4090	41.663	42.457	2.2704	.56975	.03047	1.342	1.869	.18088
180.00	2.3262	45.800	46.666	2.4956	.62129	.03322	1.331	1.861	.19640
190.00	2.2515	50.041	51.038	2.7293	.67415	.03605	1.321	1.855	.21203
200.00	2.1838	54.518	55.545	2.9703	.72826	.03894	1.311	1.849	.22772
210.00	2.1221	59.082	60.192	3.2188	.78357	.04190	1.302	1.844	.24350
220.00	2.0658	63.772	64.968	3.4742	.84001	.04492	1.293	1.839	.25940
230.00	2.0141	68.586	69.868	3.7363	.89753	.04800	1.285	1.835	.27541
240.00	1.9665	73.521	74.893	4.0050	.95609	.05113	1.277	1.831	.29147
250.00	1.9247	78.562	80.024	4.2794	1.0155	.05430	1.269	1.828	.30755
260.00	1.8838	83.725	85.281	4.5605	1.0758	.05753	1.261	1.824	.32358
270.00	1.8459	88.997	90.648	4.8475	1.1370	.06080	1.254	1.821	.33951
280.00	1.8106	94.375	96.122	5.1402	1.1991	.06412	1.247	1.818	.35531
290.00	1.7776	99.831	101.68	5.4372	1.2620	.06749	1.241	1.815	.37097
300.00	1.7469	105.41	107.35	5.7409	1.3257	.07089	1.235	1.813	.38646
310.00	1.7180	111.08	113.13	6.0497	1.3902	.07434	1.229	1.810	.40178
320.00	1.6910	116.85	119.00	6.3636	1.4554	.07783	1.223	1.808	.41695
330.00	1.6655	122.69	124.95	6.6817	1.5213	.08135	1.218	1.805	.43195
340.00	1.6416	128.64	131.00	7.0053	1.5879	.08491	1.212	1.803	.44677
350.00	1.6190	134.90	137.13	7.3334	1.6551	.08851	1.207	1.801	.46139
360.00	1.5977	140.74	143.32	7.6642	1.7229	.09213	1.202	1.799	.47583
370.00	1.5765	146.93	149.62	8.0011	1.7914	.09580	1.197	1.798	.49009
380.00	1.5574	153.21	156.01	8.3431	1.8605	.09949	1.193	1.796	.50417
390.00	1.5393	159.56	162.47	8.6853	1.9302	.10322	1.188	1.794	.51805
400.00	1.5222	165.97	169.00	9.0375	2.0003	.10697	1.184	1.793	.53173
410.00	1.5059	172.46	175.60	9.3904	2.0710	.11075	1.179	1.791	.54519
420.00	1.4904	179.01	182.27	9.7472	2.1421	.11455	1.175	1.790	.55843
430.00	1.4757	185.63	189.01	10.108	2.2137	.11838	1.171	1.788	.57145
440.00	1.4616	192.32	195.82	10.472	2.2857	.12223	1.167	1.787	.58424
450.00	1.4483	199.18	202.80	10.845	2.3582	.12611	1.163	1.785	.59679
460.00	1.4355	205.99	209.74	11.216	2.4310	.13000	1.159	1.784	.60910
470.00	1.4232	212.87	216.73	11.590	2.5043	.13392	1.155	1.783	.62116
480.00	1.4116	219.80	223.79	11.967	2.5779	.13786	1.152	1.782	.63298
490.00	1.4004	226.79	230.90	12.348	2.6519	.14181	1.148	1.780	.64455

URANIUM

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PATH LENGTH STRAGGLING GM/CH2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.3897	233.83	239.07	2.7262	1.145	.65886
510.00	1.3795	240.93	245.29	2.8009	1.142	.65893
520.00	1.3697	248.08	252.57	2.8759	1.139	.67774
530.00	1.3603	255.28	259.89	2.9512	1.136	.68829
540.00	1.3513	262.52	267.27	3.0268	1.132	.69860
550.00	1.3426	269.82	274.69	3.1027	1.130	.70865
560.00	1.3343	277.16	282.16	3.1788	1.127	.71845
570.00	1.3263	284.55	289.68	3.2553	1.124	.72799
580.00	1.3186	291.98	297.24	3.3320	1.121	.73729
590.00	1.3112	299.45	304.85	3.4089	1.118	.74635
600.00	1.3041	306.97	312.50	3.4861	1.116	.75516
620.00	1.2906	322.12	327.92	3.6412	1.110	.77205
640.00	1.2781	337.42	343.49	3.7971	1.105	.78801
660.00	1.2665	352.88	359.21	3.9538	1.101	.80305
680.00	1.2556	368.48	375.08	4.1114	1.096	.81721
700.00	1.2455	384.19	391.08	4.2696	1.092	.83051
720.00	1.2361	400.04	407.20	4.4285	1.088	.84300
740.00	1.2272	415.07	423.44	4.5880	1.084	.85469
760.00	1.2189	432.07	439.79	4.7482	1.080	.86564
780.00	1.2112	448.25	456.25	4.9089	1.076	.87587
800.00	1.2039	464.54	472.62	5.0701	1.072	.88542
820.00	1.1971	480.92	489.48	5.2318	1.069	.89432
840.00	1.1906	497.40	506.25	5.3941	1.065	.90261
860.00	1.1846	513.96	523.09	5.5567	1.062	.91033
880.00	1.1789	530.61	540.03	5.7198	1.059	.91749
900.00	1.1736	547.34	557.04	5.8833	1.056	.92414
920.00	1.1685	564.13	574.12	6.0472	1.053	.93031
940.00	1.1638	581.00	591.28	6.2115	1.051	.93602
960.00	1.1593	597.94	608.52	6.3761	1.048	.94129
1000.00	1.1511	632.50	643.65	6.7063	1.042	.95061

THE ELECTRON DENSITY OF URANIUM IS 2.329E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.896 BEV, AND THE MINIMUM ENERGY LOSS IS 1.0919 MEV/GH/CH2

# VANADIUM

ELEMENT V  
 ATOMIC NUMBER 23  
 ATOMS/MOLECULE 1  
 ATOMIC WEIGHT 50.942  
 ADJUSTED IONIZATION POTENTIAL 235.6

DENSITY = 6.0000 GM/CM<sup>3</sup>

PROTON ENERGY MEV	ENERGY LOSS GH/CM2	MEV/CM	PROTON RANGE GH/CM2	MM	PROTON PATH LENGTH MM	MG/CM2	MM	PATH LENGTH STRAGGLING MM	MG/CM2	PERCENT	MULTIPLY SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	424.18	2545.1	.42203	.00070	.43081	.00072	.01823	.00003	.01823	4.232	2.036	0.
.15	387.55	2325.3	.54488	.00091	.55408	.00092	.02018	.00003	.02018	3.642	1.661	0.
.20	354.49	2126.9	.67883	.00113	.68894	.00115	.02239	.00004	.02239	3.250	1.467	0.
.30	298.33	1790.0	.98425	.00164	.99860	.00166	.02802	.00005	.02802	2.811	1.259	0.
.40	254.19	1525.1	1.3450	.00224	1.3605	.00227	.03597	.00006	.03597	2.644	1.142	0.
.50	220.57	1323.4	1.7645	.00294	1.7835	.00297	.04595	.00008	.04595	2.576	1.065	0.
.60	195.97	1175.8	2.2425	.00374	2.2654	.00378	.05758	.00010	.05758	2.542	1.010	0.
.70	178.89	1073.3	2.7735	.00462	2.8006	.00467	.07034	.00012	.07034	2.511	.9691	0.
.80	167.81	1006.9	3.3475	.00558	3.3791	.00563	.08353	.00014	.08353	2.472	.9371	0.
.90	152.61	915.63	3.9670	.00661	4.0034	.00667	.09751	.00016	.09751	2.436	.9110	0.
1.00	137.39	824.75	4.6527	.00775	4.6940	.00782	.11348	.00019	.11348	2.418	.8886	0.
1.20	122.88	737.29	6.1822	.01030	6.2355	.01039	.14869	.00025	.14869	2.385	.8541	0.
1.40	111.67	670.04	7.8794	.01313	7.9452	.01324	.18547	.00031	.18547	2.334	.8289	0.
1.60	102.75	616.48	9.7362	.01623	9.8136	.01636	.22391	.00037	.22391	2.281	.8090	0.
1.80	95.442	572.65	11.744	.01957	11.837	.01973	.26398	.00044	.26398	2.230	.7923	0.
2.00	89.283	535.70	13.896	.02316	14.005	.02334	.30569	.00051	.30569	2.183	.7781	0.
2.20	83.997	503.98	16.190	.02698	16.315	.02719	.34903	.00058	.34903	2.139	.7654	0.
2.40	79.341	476.34	18.624	.03104	18.766	.03128	.39401	.00066	.39401	2.100	.7542	0.
2.60	75.330	451.98	21.194	.03532	21.353	.03539	.44069	.00073	.44069	2.064	.7440	0.
2.80	71.714	430.29	23.898	.03983	24.075	.04013	.48952	.00082	.48952	2.033	.7348	0.
3.00	68.470	410.82	26.735	.04456	26.930	.04488	.54050	.00090	.54050	2.007	.7261	0.
3.20	65.540	393.24	29.702	.04950	29.916	.04986	.59352	.00099	.59352	1.984	.7183	0.
3.40	62.875	377.25	32.798	.05466	33.033	.05505	.64850	.00108	.64850	1.963	.7109	.00001
3.60	60.451	362.71	36.023	.06004	36.279	.06046	.70540	.00118	.70540	1.944	.7041	.00001
3.80	58.232	349.39	39.373	.06562	39.650	.06608	.76412	.00127	.76412	1.927	.6976	.00001
4.00	56.193	337.16	42.848	.07141	43.146	.07191	.82462	.00137	.82462	1.911	.6916	.00002
4.20	54.313	325.88	46.447	.07741	46.768	.07795	.88685	.00148	.88685	1.896	.6860	.00002
4.40	52.572	315.43	50.167	.08361	50.511	.08418	.95076	.00158	.95076	1.882	.6806	.00003
4.60	50.955	305.73	54.008	.09001	54.376	.09063	1.0163	.00169	1.0163	1.869	.6755	.00003
4.80	49.446	296.68	57.969	.09662	58.361	.09727	1.0835	.00181	1.0835	1.857	.6708	.00004

VANADIUM

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	HEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
5.00	48.034	288.20	.06205	.01034	.06246	.01041	.00115	.00019	1.845	.00005
5.50	44.858	269.15	.07276	.01213	.07324	.01221	.00133	.00022	1.817	.00008
6.00	42.131	252.79	.08420	.01403	.08475	.01413	.00152	.00025	1.793	.00011
6.50	39.748	238.49	.09636	.01606	.09698	.01616	.00172	.00029	1.771	.00015
7.00	37.685	226.11	.10921	.01820	.10990	.01832	.00192	.00032	1.751	.00020
7.50	35.844	215.07	.12274	.02046	.12351	.02059	.00214	.00036	1.732	.00025
8.00	34.195	205.17	.13695	.02282	.13780	.02297	.00236	.00039	1.714	.00031
8.50	32.708	196.25	.15182	.02530	.15273	.02546	.00259	.00043	1.698	.00038
9.00	31.359	188.15	.16734	.02782	.16836	.02806	.00283	.00047	1.683	.00046
9.50	30.129	180.77	.18353	.03059	.18464	.03077	.00308	.00051	1.669	.00054
10.00	29.002	174.01	.20036	.03339	.20156	.03359	.00334	.00056	1.656	.00064
11.00	27.009	162.06	.23592	.03932	.23731	.03955	.00387	.00065	1.632	.00085
12.00	25.300	151.80	.27399	.04566	.27559	.04593	.00444	.00074	1.612	.00118
13.00	23.815	142.89	.31454	.05242	.31635	.05273	.00504	.00084	1.592	.00327
14.00	22.514	135.09	.35751	.05959	.35956	.05993	.00566	.00094	1.574	.00584
15.00	21.353	128.18	.40289	.06715	.40518	.06753	.00632	.00105	1.559	.00843
16.00	20.337	122.02	.45064	.07511	.45317	.07553	.00700	.00117	1.544	.01104
17.00	19.416	116.50	.50071	.08345	.50350	.08392	.00771	.00128	1.531	.01367
18.00	18.585	111.51	.55310	.09218	.55616	.09269	.00845	.00141	1.519	.01632
19.00	17.830	106.98	.60778	.10130	.61112	.10185	.00921	.00154	1.508	.01899
20.00	17.141	102.85	.66470	.11078	.66833	.11139	.01000	.00167	1.497	.02168
22.00	15.930	95.579	.78523	.13087	.78946	.13158	.01167	.00194	1.478	.02712
24.00	14.897	89.383	.91449	.15242	.91938	.15323	.01343	.00224	1.461	.03263
26.00	14.006	84.034	1.0523	.17539	1.0579	.17632	.01529	.00255	1.445	.03822
28.00	13.227	79.360	1.1986	.19977	1.2049	.20082	.01725	.00287	1.432	.03781
30.00	12.541	75.247	1.3532	.22554	1.3603	.22671	.01930	.00322	1.419	.03947
32.00	11.932	71.592	1.5160	.25267	1.5238	.25397	.02145	.00357	1.407	.04120
34.00	11.387	68.322	1.6868	.28113	1.6955	.28258	.02368	.00395	1.397	.04300
36.00	10.896	65.378	1.8695	.31092	1.8751	.31251	.02601	.00433	1.387	.04485
38.00	10.452	62.711	2.0521	.34202	2.0625	.34376	.02842	.00474	1.378	.04676
40.00	10.047	60.284	2.2464	.37440	2.2573	.37629	.03091	.00515	1.369	.04872
45.00	9.1785	55.071	2.7652	.46087	2.7791	.46318	.03752	.00625	1.350	.05384
50.00	8.4675	50.805	3.3303	.55505	3.3468	.55780	.04462	.00744	1.333	.05923
55.00	7.8743	47.246	3.9403	.65671	3.9596	.65994	.05220	.00870	1.318	.06488
60.00	7.3714	44.229	4.5939	.76565	4.6164	.76939	.06025	.01004	1.305	.07079
65.00	6.9388	41.633	5.2981	.88170	5.3159	.88598	.06875	.01146	1.293	.07693
70.00	6.5634	39.380	6.0281	1.0047	6.0372	1.0095	.07768	.01295	1.282	.08328
75.00	6.2342	37.405	6.8064	1.1344	6.8391	1.1398	.08702	.01450	1.272	.08981
80.00	5.9428	35.657	7.6244	1.2707	7.6609	1.2768	.09677	.01613	1.263	.09649
90.00	5.4499	32.703	9.3757	1.5626	9.4203	1.5700	.11742	.01957	1.247	.11022



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PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GH/CH2	MEV/CH	GH/CH2	CH	GH/CH2	CH	GH/CH2	CH			
100.00	5.0487	30.292	11.275	1.6792	11.329	1.8881	.13955	.02326	1.232	.4697	.12430
110.00	4.7155	28.293	13.317	2.2195	13.380	2.2300	.16306	.02718	1.219	.4671	.13881
120.00	4.4342	26.605	15.496	2.5826	15.568	2.5947	.18787	.03131	1.207	.4650	.15384
130.00	4.1936	25.161	17.806	2.9676	17.688	2.9814	.21393	.03566	1.196	.4631	.16931
140.00	3.9853	23.912	20.242	3.3737	20.336	3.3893	.24116	.04019	1.186	.4615	.18514
150.00	3.8032	22.819	22.800	3.8000	22.905	3.8176	.26950	.04492	1.177	.4600	.20124
160.00	3.6427	21.856	25.476	4.2460	25.593	4.2655	.29891	.04932	1.166	.4587	.21759
170.00	3.5001	21.000	28.265	4.7108	28.395	4.7324	.32932	.05489	1.160	.4576	.23419
180.00	3.3726	20.235	31.163	5.1939	31.306	5.2177	.36069	.06011	1.152	.4565	.25096
190.00	3.2579	19.547	34.167	5.6945	34.324	5.7206	.39297	.06549	1.145	.4555	.26786
200.00	3.1542	18.925	37.274	6.2123	37.444	6.2406	.42612	.07102	1.138	.4547	.28484
210.00	3.0600	18.360	40.479	6.7464	40.663	6.7772	.46011	.07668	1.132	.4539	.30184
220.00	2.9741	17.844	43.779	7.2966	43.979	7.3298	.49489	.08248	1.125	.4531	.31884
230.00	2.8954	17.372	47.173	7.8621	47.387	7.8978	.53043	.08840	1.119	.4524	.33580
240.00	2.8230	16.938	50.655	8.4426	50.885	8.4809	.56669	.09445	1.114	.4518	.35268
250.00	2.7563	16.538	54.225	9.0375	54.471	9.0784	.60365	.10061	1.108	.4511	.36944
260.00	2.6946	16.168	57.878	9.6464	58.140	9.6901	.64128	.10688	1.103	.4506	.38610
270.00	2.6374	15.824	61.614	10.269	61.692	10.318	.67954	.11326	1.098	.4500	.40269
280.00	2.5842	15.505	65.428	10.905	65.723	10.934	.71841	.11973	1.093	.4495	.41916
290.00	2.5346	15.208	69.318	11.553	69.631	11.605	.75787	.12631	1.088	.4490	.43550
300.00	2.4883	14.930	73.283	12.214	73.613	12.269	.79788	.13298	1.084	.4486	.45167
310.00	2.4450	14.670	77.319	12.887	77.668	12.945	.83844	.13974	1.080	.4481	.46766
320.00	2.4043	14.426	81.426	13.571	81.792	13.632	.87952	.14659	1.075	.4477	.48341
330.00	2.3661	14.197	85.601	14.267	85.985	14.331	.92139	.15351	1.071	.4473	.49893
340.00	2.3302	13.981	89.841	14.974	90.244	15.041	.96314	.16052	1.067	.4469	.51419
350.00	2.2963	13.778	94.145	15.691	94.568	15.761	1.0056	.16761	1.063	.4465	.52918
360.00	2.2643	13.586	98.512	16.419	98.953	16.492	1.0486	.17477	1.060	.4461	.54394
370.00	2.2341	13.405	102.94	17.156	103.40	17.233	1.0920	.18200	1.056	.4457	.55851
380.00	2.2055	13.233	107.42	17.904	107.90	17.984	1.1358	.18929	1.053	.4453	.57287
390.00	2.1784	13.070	111.97	18.661	112.47	18.745	1.1799	.19666	1.049	.4450	.58702
400.00	2.1527	12.916	116.56	19.427	117.09	19.514	1.2245	.20408	1.046	.4446	.60093
410.00	2.1283	12.770	121.22	20.203	121.76	20.293	1.2694	.21157	1.043	.4443	.61456
420.00	2.1050	12.630	125.92	20.987	126.48	21.080	1.3147	.21912	1.039	.4440	.62787
430.00	2.0829	12.498	130.68	21.779	131.26	21.876	1.3603	.22672	1.036	.4436	.64086
440.00	2.0619	12.371	135.48	22.580	136.08	22.681	1.4063	.23438	1.033	.4433	.65353
450.00	2.0418	12.251	140.33	23.389	140.96	23.493	1.4525	.24209	1.030	.4430	.66587
460.00	2.0226	12.136	145.23	24.206	146.88	24.313	1.4991	.24985	1.028	.4427	.67789
470.00	2.0043	12.026	150.18	25.030	150.85	25.141	1.5460	.25766	1.025	.4424	.68958
480.00	1.9868	11.921	155.17	25.861	155.86	25.976	1.5931	.26552	1.022	.4420	.70095
490.00	1.9700	11.820	160.20	26.700	160.91	26.819	1.6405	.27342	1.020	.4417	.71199

VANADIUM

PROCTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GH/CM2	CM	GH/CM2	CM	GH/CM2	CM		
500.00	1.9540	165.28	27.546	166.01	27.668	1.6882	.28137	1.017	.72272
510.00	1.9386	170.39	28.399	171.15	28.525	1.7362	.28936	1.014	.73313
520.00	1.9239	175.55	29.258	176.33	29.388	1.7844	.29739	1.012	.74322
530.00	1.9097	180.74	30.124	181.54	30.257	1.8328	.30546	1.010	.75301
540.00	1.8962	185.98	30.996	186.80	31.133	1.8815	.31358	1.007	.76249
550.00	1.8831	191.24	31.874	192.09	32.015	1.9304	.32173	1.005	.77168
560.00	1.8706	196.55	32.758	197.42	32.903	1.9795	.32991	1.003	.78055
570.00	1.8586	201.89	33.646	202.78	33.797	2.0288	.33813	1.000	.78916
580.00	1.8470	207.26	34.544	208.18	34.696	2.0783	.34639	.9983	.79747
590.00	1.8358	212.67	35.445	213.61	35.602	2.1280	.35467	.9962	.80551
600.00	1.8251	218.11	36.352	219.07	36.512	2.1780	.36299	.9942	.81327
620.00	1.8047	229.09	38.181	230.09	38.349	2.2784	.37973	.9902	.82800
640.00	1.7858	240.18	40.030	241.23	40.206	2.3795	.39658	.9864	.84171
660.00	1.7682	251.29	41.898	252.45	42.082	2.4812	.41354	.9827	.85446
680.00	1.7518	262.40	43.784	263.85	43.976	2.5836	.43060	.9792	.86629
700.00	1.7365	274.12	45.687	275.32	45.887	2.6866	.44776	.9758	.87726
720.00	1.7221	285.64	47.607	286.89	47.815	2.7901	.46502	.9725	.88741
740.00	1.7087	297.25	49.542	298.55	49.758	2.8942	.48237	.9694	.89680
760.00	1.6960	308.95	51.492	310.30	51.716	2.9988	.49979	.9664	.90547
780.00	1.6842	320.74	53.456	322.13	53.689	3.1038	.51730	.9635	.91346
800.00	1.6731	332.60	55.434	334.05	55.675	3.2093	.53489	.9607	.92063
820.00	1.6626	344.55	57.424	346.04	57.673	3.3152	.55254	.9581	.92762
840.00	1.6528	356.56	59.427	358.11	59.685	3.4216	.57026	.9555	.93386
860.00	1.6435	368.65	61.442	370.24	61.707	3.5283	.58805	.9530	.93960
880.00	1.6348	380.81	63.468	382.45	63.742	3.6354	.60590	.9504	.94486
900.00	1.6265	393.03	65.504	394.72	65.787	3.7429	.62381	.9482	.94976
920.00	1.6188	405.31	67.552	407.06	67.843	3.8507	.64178	.9460	.95413
940.00	1.6114	417.66	69.610	419.45	69.909	3.9588	.65980	.9438	.95819
960.00	1.6045	430.08	71.679	431.92	71.987	4.0673	.67788	.9417	.96190
980.00	1.5917	455.19	75.866	457.14	76.189	4.2850	.71417	.9374	.96842

THE ELECTRON DENSITY OF VANADIUM IS 2.720E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.123 BEV, AND THE MINIMUM ENERGY LOSS IS 1.4993 MEV/GM/CM2

XENON

ATOMIC NUMBER 54  
ELEMENT Xe  
ATOMS/MOLECULE 1  
ATOMIC WEIGHT 131.30  
ADJUSTED IONIZATION POTENTIAL 535.4

DENSITY = 5.8960 MG/CM3

PROTON ENERGY MEV	ENERGY LOSS KEV/CM	PROTON RANGE MG/CM2	PROTON PATH LENGTH MG/CM2	ATOMIC WEIGHT 131.30	ADJUSTED IONIZATION POTENTIAL 535.4	PATH LENGTH STRAGGLING MG/CM2	PATH LENGTH MEYER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	229.89	.45564	.00078	.47850	.00081	.02311	.00004	3.941	0.
.15	207.56	.68677	.00116	.70730	.00120	.03066	.00005	2.903	0.
.20	190.99	.93403	.00158	.95837	.00163	.03849	.00007	2.540	0.
.30	163.39	1.4897	.00253	1.5249	.00259	.05493	.00009	2.309	0.
.40	142.31	2.1334	.00362	2.1823	.00370	.07312	.00012	2.240	0.
.50	127.31	2.8616	.00485	2.9262	.00496	.09413	.00016	2.206	0.
.60	114.89	3.6715	.00623	3.7534	.00637	.11845	.00020	2.183	0.
.70	106.04	4.5585	.00773	4.6593	.00790	.14496	.00025	2.163	0.
.80	97.494	5.5194	.00936	5.6403	.00957	.17318	.00029	2.144	0.
.90	89.374	6.5656	.01114	6.7082	.01138	.20406	.00035	2.125	0.
1.00	80.751	7.7188	.01309	7.8851	.01337	.23916	.00041	2.108	0.
1.20	74.067	10.254	.01739	10.472	.01776	.31354	.00053	2.080	0.
1.40	68.466	13.009	.02206	13.282	.02253	.38766	.00066	2.056	0.
1.60	63.750	15.982	.02711	16.314	.02767	.46308	.00079	2.033	0.
1.80	59.746	19.166	.03251	19.559	.03317	.54041	.00092	2.010	0.
2.00	55.301	22.550	.03825	23.007	.03902	.61989	.00105	1.988	0.
2.20	51.297	26.134	.04433	26.658	.04521	.70169	.00119	1.966	0.
2.40	47.656	29.917	.05074	30.511	.05175	.78589	.00133	1.945	0.
2.60	44.375	33.687	.05748	34.553	.05860	.87358	.00148	1.925	0.
2.80	41.331	38.039	.06452	38.778	.06577	.96484	.00164	1.906	0.
3.00	38.485	42.369	.07186	43.185	.07324	1.0593	.00180	1.887	0.
3.20	35.812	46.875	.07950	47.768	.08102	1.1568	.00196	1.870	0.
3.40	33.274	51.555	.08744	52.528	.08909	1.2571	.00213	1.853	0.
3.60	30.886	56.406	.09567	57.461	.09745	1.3600	.00231	1.837	0.
3.80	28.606	61.416	.10417	62.555	.10610	1.4653	.00249	1.821	0.
4.00	26.421	66.592	.11295	67.818	.11502	1.5730	.00267	1.807	0.
4.20	24.315	71.931	.12200	73.244	.12423	1.6829	.00285	1.792	0.
4.40	22.296	77.427	.13132	78.829	.13370	1.7951	.00304	1.779	0.
4.60	20.338	83.082	.14091	84.575	.14345	1.9093	.00324	1.765	0.
4.80	18.439	88.893	.15077	90.479	.15346	2.0257	.00344	1.753	0.

XENON

PROCTON ENERGY MEV	ENERGY LOSS HEV/ GN/CM2	PROTON RANGE GN/CM2	PROTON PATH LENGTH GN/CM2	PATH LENGTH STRAGGLING GN/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	32.594	0.9486	0.9654	0.0214	1.741	0.
5.50	30.687	1.1043	1.1235	0.0245	1.713	0.
6.00	29.024	1.2694	1.2912	0.0277	1.687	0.
6.50	27.558	1.4336	1.4681	0.0310	1.663	0.
7.00	26.255	1.6268	1.6540	0.0344	1.641	0.0001
7.50	25.089	1.8189	1.8489	0.0379	1.621	0.0001
8.00	24.036	2.0196	2.0525	0.0415	1.603	0.0002
8.50	23.084	2.2290	2.2649	0.0453	1.585	0.0003
9.00	22.214	2.4467	2.4857	0.0491	1.569	0.0004
9.50	21.416	2.6728	2.7150	0.0531	1.554	0.0006
10.00	20.653	2.9071	2.9526	0.0572	1.540	0.0009
11.00	19.379	3.4002	3.4524	0.0656	1.514	0.0015
12.00	18.302	3.9248	3.9842	0.0744	1.491	0.0023
13.00	17.322	4.4790	4.5458	0.0836	1.470	0.0033
14.00	16.454	5.0636	5.1382	0.0931	1.451	0.0047
15.00	15.682	5.6786	5.7612	0.1030	1.434	0.0062
16.00	14.987	6.3232	6.4142	0.1133	1.418	0.0080
17.00	14.364	6.9961	7.0957	0.1239	1.404	0.0101
18.00	13.796	7.6974	7.8059	0.1350	1.390	0.0124
19.00	13.279	8.4273	8.5451	0.1464	1.378	0.0149
20.00	12.804	9.1852	9.3124	0.1581	1.366	0.0176
22.00	11.961	1.0783	1.0930	0.1827	1.346	0.0433
24.00	11.235	1.2488	1.2656	0.2087	1.327	0.0825
26.00	10.604	1.4299	1.4489	0.2361	1.311	0.1095
28.00	10.048	1.6215	1.6428	0.2647	1.296	0.1238
30.00	9.5561	1.8232	1.8469	0.2946	1.283	0.1387
32.00	9.1168	2.0351	2.0613	0.3257	1.271	0.1541
34.00	8.7219	2.2568	2.2878	0.3580	1.261	0.1701
36.00	8.3651	2.4883	2.5198	0.3915	1.251	0.1866
38.00	8.0396	2.7296	2.7639	0.4261	1.241	0.2036
40.00	7.7428	2.9803	3.0175	0.4618	1.233	0.2211
45.00	7.1028	3.6477	3.6926	0.5560	1.215	0.2666
50.00	6.5790	4.3716	4.4247	0.6565	1.199	0.3146
55.00	6.1388	5.1504	5.2122	0.7632	1.186	0.3650
60.00	5.7637	5.9821	6.0532	0.8758	1.175	0.4179
65.00	5.4398	6.8660	6.9469	0.9942	1.165	0.4732
70.00	5.1572	7.8002	7.8914	1.1180	1.156	0.5307
75.00	4.9084	8.7836	8.8856	1.2471	1.148	0.5900
80.00	4.6876	9.8151	9.9284	1.3814	1.141	0.6512
90.00	4.3126	12.018	12.155	1.6647	1.129	0.7781

XENON

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	KEV/CM	GM/CM2	METER	GM/CM2	METER	GM/CM2	METER PERCENT		
100.00	4.0060	23.619	14.400	24.424	14.564	24.701	.19666	.33354	1.350	.09101
110.00	3.7504	22.113	16.955	28.757	17.145	29.090	.22860	.38772	1.333	.10472
120.00	3.5340	20.837	19.674	33.369	19.894	33.742	.26220	.44470	1.318	.11895
130.00	3.3454	19.742	22.552	38.250	22.803	38.675	.29735	.50433	1.304	.13361
140.00	3.1873	18.792	25.583	43.390	25.865	43.869	.33398	.56646	1.291	.14864
150.00	3.0462	17.960	28.760	48.778	29.076	49.315	.37201	.63095	1.279	.16396
160.00	2.9236	17.237	32.076	54.402	32.427	54.998	.41129	.69757	1.268	.17955
170.00	2.8124	16.582	35.525	60.253	35.913	60.911	.45183	.76633	1.258	.19540
180.00	2.7129	15.995	39.111	66.334	39.536	67.056	.49358	.83714	1.248	.21145
190.00	2.6233	15.467	42.823	72.630	43.288	73.419	.53647	.90989	1.239	.22767
200.00	2.5422	14.989	46.652	79.125	47.157	79.982	.58046	.98449	1.231	.24400
210.00	2.4685	14.554	50.605	85.829	51.151	86.756	.62548	1.0608	1.223	.26038
220.00	2.4012	14.157	54.671	92.726	55.261	93.726	.67148	1.1399	1.215	.27674
230.00	2.3394	13.793	58.849	99.812	59.482	100.89	.71843	1.2185	1.208	.29304
240.00	2.2826	13.458	63.130	107.07	63.808	108.22	.76628	1.2997	1.201	.30925
250.00	2.2296	13.146	67.520	114.52	68.243	115.75	.81502	1.3823	1.194	.32535
260.00	2.1811	12.860	72.008	122.13	72.778	123.44	.86459	1.4664	1.188	.34139
270.00	2.1362	12.595	76.591	129.90	77.409	131.29	.91495	1.5518	1.182	.35744
280.00	2.0943	12.348	81.270	137.84	82.137	139.31	.96605	1.6385	1.176	.37345
290.00	2.0553	12.118	86.046	145.94	86.963	147.50	1.0179	1.7264	1.170	.38942
300.00	2.0188	11.903	90.905	154.18	91.873	155.82	1.0704	1.8154	1.165	.40531
310.00	1.9847	11.702	95.845	162.56	96.864	164.29	1.1236	1.9056	1.160	.42107
320.00	1.9527	11.513	100.87	171.09	101.94	172.90	1.1774	1.9969	1.155	.43664
330.00	1.9226	11.336	105.98	179.75	107.11	181.66	1.2318	2.0891	1.150	.45201
340.00	1.8943	11.169	111.17	188.55	112.35	190.54	1.2867	2.1824	1.145	.46716
350.00	1.8676	11.011	116.43	197.47	117.66	199.56	1.3423	2.2766	1.141	.48208
360.00	1.8424	10.863	121.76	206.52	123.05	208.71	1.3984	2.3717	1.136	.49679
370.00	1.8185	10.722	127.18	215.70	128.52	217.99	1.4550	2.4677	1.132	.51130
380.00	1.7960	10.589	132.66	224.99	134.06	227.37	1.5121	2.5645	1.128	.52560
390.00	1.7746	10.463	138.20	234.40	139.66	236.87	1.5696	2.6622	1.124	.53968
400.00	1.7543	10.343	143.81	243.91	145.33	246.48	1.6276	2.7606	1.120	.55353
410.00	1.7350	10.230	149.48	253.53	151.06	256.21	1.6861	2.8597	1.116	.56713
420.00	1.7167	10.122	155.22	263.26	156.85	266.03	1.7450	2.9596	1.112	.58050
430.00	1.6992	10.019	161.01	273.09	162.71	275.97	1.8043	3.0602	1.109	.59361
440.00	1.6826	9.9207	166.87	283.02	168.62	286.00	1.8640	3.1614	1.105	.60646
450.00	1.6668	9.8273	172.78	293.04	174.59	296.12	1.9240	3.2633	1.102	.61905
460.00	1.6516	9.7380	178.74	303.15	180.62	306.34	1.9845	3.3658	1.099	.63138
470.00	1.6372	9.6528	184.76	313.36	186.70	316.65	2.0452	3.4688	1.095	.64343
480.00	1.6234	9.5714	190.83	323.66	192.83	327.05	2.1063	3.5725	1.092	.65522
490.00	1.6102	9.4935	196.95	334.04	199.02	337.54	2.1678	3.6767	1.089	.66673

XENON

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	METER	GM/CM2	METER	GM/CM2	METER PERCENT		
500.00	1.5975	9.4189	344.51	205.25	348.12	2.2295	3.7815	1.037	.67797
510.00	1.5854	9.3474	355.06	211.54	358.78	2.2916	3.8867	1.036	.68893
520.00	1.5738	9.2789	365.69	217.87	369.52	2.3540	3.9925	1.035	.69962
530.00	1.5626	9.2132	376.39	224.24	380.33	2.4166	4.0987	1.035	.71004
540.00	1.5519	9.1501	387.18	230.66	391.22	2.4795	4.2054	1.034	.72019
550.00	1.5416	9.0895	398.04	237.14	402.20	2.5427	4.3126	1.034	.73006
560.00	1.5318	9.0313	408.96	243.64	413.23	2.6061	4.4201	1.033	.73967
570.00	1.5223	8.9754	419.96	250.19	424.34	2.6698	4.5281	1.032	.74901
580.00	1.5132	8.9216	431.02	256.78	435.52	2.7337	4.6366	1.032	.75809
590.00	1.5044	8.8698	442.15	263.41	446.76	2.7979	4.7453	1.031	.76691
600.00	1.4959	8.8199	453.34	270.07	458.06	2.8622	4.8545	1.031	.77547
620.00	1.4799	8.7257	475.91	283.52	480.86	2.9916	5.0740	1.030	.79184
640.00	1.4651	8.6380	498.71	297.10	503.90	3.1218	5.2948	1.028	.80723
660.00	1.4512	8.5565	521.75	310.81	527.16	3.2528	5.5169	1.027	.82167
680.00	1.4383	8.4804	544.99	324.66	550.64	3.3844	5.7452	1.026	.83520
700.00	1.4263	8.4095	568.44	338.63	574.33	3.5168	5.9647	1.025	.84785
720.00	1.4151	8.3432	592.08	352.79	598.21	3.6497	6.1902	1.024	.85967
740.00	1.4045	8.2811	615.91	366.89	622.27	3.7833	6.4167	1.023	.87070
760.00	1.3947	8.2230	639.90	381.18	646.51	3.9174	6.6442	1.022	.88096
780.00	1.3854	8.1685	664.06	395.57	670.91	4.0521	6.8726	1.021	.89051
800.00	1.3768	8.1174	688.38	410.05	695.47	4.1873	7.1019	1.021	.89938
820.00	1.3686	8.0694	712.85	424.62	720.18	4.3229	7.3320	1.018	.90761
840.00	1.3610	8.0242	737.46	439.28	745.04	4.4590	7.5628	1.017	.91524
860.00	1.3538	7.9818	762.26	454.04	770.09	4.5955	7.7943	1.016	.92230
880.00	1.3470	7.9418	787.30	468.95	795.37	4.7325	8.0266	1.015	.92883
900.00	1.3406	7.9042	812.31	483.84	820.63	4.8698	8.2594	1.013	.93486
920.00	1.3346	7.8687	837.57	498.89	846.14	5.0074	8.4930	1.014	.94042
940.00	1.3289	7.8353	862.85	513.95	871.67	5.1455	8.7271	1.012	.94555
960.00	1.3236	7.8037	888.13	528.96	897.18	5.2838	8.9617	1.009	.95026
1000.00	1.3137	7.7458	939.56	553.96	949.09	5.5615	9.4327	1.005	.95854

THE ELECTRON DENSITY OF XENON IS 2.478E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.985 BEV, AND THE MINIMUM ENERGY LOSS IS 1.2409 MEV/GM/CM2

# ZINC

ELEMENT ZN  
 ATOMIC NUMBER 30  
 ATOMS/MOLECULE 1  
 ADJUSTED IONIZATION POTENTIAL 330.9  
 ATOMIC WEIGHT 65.370

DENSITY = 7.1330 GR/CM3

PROTON ENERGY MEV	ENERGY LOSS MEV/CM2	PROTON RANGE MG/CM2	PROTON PATH LENGTH MG/CM2	PROTON PATH LENGTH MM	HQ/CM2	PATH LENGTH STRAGGLING MM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	235.94	52830	.54185	.00076	.02394	.00003	2.501	0.
.15	230.53	.74123	.75624	.00106	.03193	.00004	1.985	0.
.20	218.84	.96089	.97881	.00137	.03677	.00005	1.831	0.
.30	194.08	1.4391	1.4644	.00205	.05197	.00007	1.728	0.
.40	175.37	1.9737	2.0073	.00281	.06551	.00009	1.678	0.
.50	160.34	2.5613	2.6039	.00365	.07951	.00011	1.635	0.
.60	146.93	3.2038	3.2557	.00449	.09497	.00013	1.595	0.
.70	137.32	3.8997	3.9613	.00555	.11211	.00016	1.557	0.
.80	129.69	4.6375	4.7091	.00660	.12990	.00018	1.521	0.
.90	124.33	5.4143	5.4961	.00771	.14810	.00021	1.488	0.
1.00	118.97	6.2266	6.3187	.00886	.16644	.00023	1.457	0.
1.20	107.48	7.9767	8.0900	.01134	.20521	.00029	1.400	0.
1.40	98.353	9.9021	10.038	.01407	.24712	.00035	1.349	0.
1.60	90.824	11.997	12.156	.01704	.29182	.00041	1.305	0.
1.80	84.564	14.257	14.440	.02024	.33908	.00048	1.267	0.
2.00	79.387	16.673	16.882	.02367	.38862	.00054	1.232	0.
2.20	74.905	19.243	19.477	.02731	.44020	.00062	1.202	0.
2.40	70.977	21.960	22.221	.03115	.49376	.00069	1.175	0.
2.60	67.505	24.823	25.112	.03521	.54925	.00077	1.151	0.
2.80	64.411	27.827	28.145	.03946	.60660	.00085	1.129	0.
3.00	61.659	30.973	31.321	.04391	.66579	.00093	1.109	0.
3.20	59.169	34.252	34.630	.04855	.72672	.00102	1.091	0.
3.40	56.905	37.669	38.078	.05338	.78937	.00111	1.074	0.
3.60	54.834	41.220	41.661	.05841	.85370	.00120	1.059	0.
3.80	52.930	44.901	45.375	.06361	.91971	.00129	1.045	0.
4.00	51.174	48.708	49.215	.06900	.98737	.00138	1.031	0.
4.20	49.547	52.648	53.190	.07457	1.0567	.00148	1.019	0.
4.40	48.034	56.712	57.289	.08032	1.1276	.00158	1.007	.00001
4.60	46.623	60.903	61.516	.08624	1.2002	.00168	.9966	.00001
4.80	45.303	65.220	65.870	.09235	1.2749	.00179	.9864	.00001

# ZINC

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	44.066	0.0977	0.07034	0.00135	1.921	.00002
5.50	41.282	0.1140	0.08208	0.00155	1.890	.00003
6.00	38.869	0.1313	0.09368	0.00176	1.863	.00005
6.50	36.755	0.1497	0.10760	0.00198	1.840	.00007
7.00	34.888	0.1692	0.12177	0.00222	1.819	.00010
7.50	33.224	0.1896	0.13646	0.00246	1.801	.00013
8.00	31.735	0.2110	0.15186	0.00271	1.784	.00018
8.50	30.390	0.2334	0.16797	0.00297	1.768	.00023
9.00	29.189	0.2568	0.18476	0.00324	1.753	.00028
9.50	28.067	0.2811	0.20223	0.00352	1.739	.00035
10.00	27.037	0.3064	0.22039	0.00380	1.726	.00042
11.00	25.216	0.3597	0.25871	0.00440	1.702	.00058
12.00	23.652	0.4167	0.29968	0.00504	1.681	.00077
13.00	22.309	0.4773	0.34323	0.00570	1.661	.00099
14.00	21.127	0.5415	0.38932	0.00640	1.643	.00124
15.00	20.078	0.6091	0.43790	0.00712	1.627	.00152
16.00	19.141	0.6802	0.48917	0.00788	1.612	.00179
17.00	18.296	0.7545	0.54235	0.00867	1.598	.00214
18.00	17.532	0.8323	0.59822	0.00948	1.585	.00250
19.00	16.836	0.9134	0.65643	0.01032	1.573	.00288
20.00	16.201	0.9977	0.71699	0.01119	1.561	.00328
22.00	15.079	1.1761	0.84508	0.01302	1.540	.00413
24.00	14.120	1.3670	0.97511	0.01495	1.522	.00505
26.00	13.291	1.5705	1.12833	0.01698	1.505	.00603
28.00	12.565	1.7861	1.2831	0.01912	1.493	.00707
30.00	11.925	2.0138	1.4466	0.02136	1.477	.00813
32.00	11.355	2.2533	1.6185	0.02369	1.464	.00922
34.00	10.845	2.5044	1.7988	0.02612	1.452	.01038
36.00	10.385	2.7669	1.9873	0.02865	1.442	.01149
38.00	9.9684	3.0409	2.1839	0.03126	1.431	.01266
40.00	9.5886	3.3259	2.3885	0.03397	1.422	.01385
45.00	8.7717	4.0863	2.9344	0.04111	1.401	.01666
50.00	8.1015	4.9135	3.5281	0.04877	1.382	.01987
55.00	7.5421	5.8054	4.1683	0.05695	1.366	.02341
60.00	7.0571	6.7602	4.8536	0.06561	1.352	.02723
65.00	6.6385	7.7764	5.5829	0.07473	1.339	.03129
70.00	6.3030	8.8522	6.3551	0.08433	1.327	.03559
75.00	5.9908	9.9865	7.1691	0.09431	1.316	.03908
80.00	5.7143	1.1178	8.0240	0.10475	1.305	.04275
90.00	5.2457	1.3726	9.8527	0.12682	1.287	.04956



# ZINC

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CH	GM/CM2	CH		
100.00	4.8639	11.761	1.6487	11.834	1.6591	.15043	.02109	1.271	.11385
110.00	4.5465	13.876	1.9453	13.963	1.9575	.17549	.02460	1.257	.12861
120.00	4.2784	16.131	2.2615	16.231	2.2755	.20190	.02831	1.244	.14383
130.00	4.0489	18.521	2.5965	18.635	2.6125	.22961	.03219	1.232	.15942
140.00	3.8500	21.040	2.9496	21.169	2.9678	.25853	.03624	1.221	.17530
150.00	3.6760	23.683	3.3202	23.828	3.3406	.28861	.04046	1.211	.19137
160.00	3.5225	26.447	3.7076	26.608	3.7303	.31978	.04483	1.202	.20767
170.00	3.3861	29.326	4.1113	29.505	4.1364	.35201	.04935	1.193	.22422
180.00	3.2640	32.317	4.5356	32.513	4.5581	.38522	.05401	1.185	.24097
190.00	3.1542	35.416	4.9650	35.630	4.9851	.41939	.05880	1.177	.25787
200.00	3.0549	38.619	5.4141	38.853	5.4469	.45445	.06371	1.170	.27487
210.00	2.9646	41.923	5.8773	42.176	5.9128	.49038	.06875	1.163	.29194
220.00	2.8822	45.325	6.3542	45.598	6.3925	.52713	.07390	1.156	.30906
230.00	2.8067	48.820	6.8443	49.114	6.8855	.56467	.07916	1.150	.32620
240.00	2.7373	52.408	7.3472	52.722	7.3913	.60295	.08453	1.144	.34332
250.00	2.6733	56.083	7.8625	56.420	7.9097	.64196	.09000	1.138	.36038
260.00	2.6140	59.845	8.3898	60.203	8.4401	.68165	.09556	1.132	.37734
270.00	2.5591	63.629	8.9287	64.070	8.9821	.72199	.10122	1.127	.39416
280.00	2.5080	67.613	9.4789	68.017	9.5356	.76297	.10696	1.122	.41071
290.00	2.4604	71.616	10.040	72.043	10.100	.80455	.11279	1.117	.42728
300.00	2.4159	75.694	10.612	76.145	10.675	.84671	.11870	1.112	.44353
310.00	2.3743	79.845	11.194	80.320	11.250	.88942	.12469	1.107	.45958
320.00	2.3352	84.068	11.786	84.568	11.856	.93267	.13075	1.103	.47545
330.00	2.2985	88.359	12.387	88.884	12.461	.97643	.13689	1.099	.49110
340.00	2.2640	92.718	12.998	93.268	13.076	1.0207	.14309	1.094	.50653
350.00	2.2314	97.141	13.619	97.717	13.699	1.0654	.14936	1.090	.52172
360.00	2.2007	101.63	14.248	102.23	14.332	1.1106	.15570	1.086	.53667
370.00	2.1717	106.18	14.885	106.80	14.973	1.1562	.16209	1.083	.55135
380.00	2.1442	110.78	15.531	111.44	15.623	1.2022	.16854	1.079	.56577
390.00	2.1181	115.45	16.185	116.13	16.281	1.2487	.17505	1.075	.57991
400.00	2.0934	120.17	16.847	120.88	16.947	1.2955	.18162	1.072	.59377
410.00	2.0699	124.95	17.517	125.68	17.620	1.3427	.18823	1.069	.60733
420.00	2.0476	129.78	18.194	130.54	18.301	1.3902	.19490	1.065	.62060
430.00	2.0263	134.66	18.878	135.45	18.989	1.4381	.20162	1.062	.63355
440.00	2.0061	139.59	19.570	140.41	19.685	1.4864	.20838	1.059	.64620
450.00	1.9868	144.57	20.268	145.42	20.387	1.5349	.21519	1.056	.65854
460.00	1.9684	149.60	20.973	150.48	21.096	1.5838	.22204	1.053	.67056
470.00	1.9508	154.67	21.684	155.58	21.811	1.6330	.22893	1.050	.68228
480.00	1.9339	159.79	22.402	160.73	22.533	1.6825	.23587	1.047	.69368
490.00	1.9178	164.95	23.126	165.92	23.261	1.7322	.24284	1.044	.70477

# ZINC

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON RANGE CM	PATH LENGTH GM/CM2	PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.9024	13.570	170.16	23.995	171.16	1.7822	.24986	1.041	.71555
510.00	1.8876	13.465	175.41	24.591	176.43	1.8325	.25690	1.039	.72603
520.00	1.8735	13.364	180.69	25.332	181.75	1.8830	.26399	1.036	.73620
530.00	1.8599	13.267	186.02	26.079	187.11	1.9338	.27111	1.034	.74607
540.00	1.8469	13.174	191.39	26.831	192.50	1.9848	.27825	1.031	.75565
550.00	1.8343	13.084	196.79	27.588	197.94	2.0361	.28544	1.029	.76493
560.00	1.8223	12.999	202.23	28.351	203.41	2.0875	.29266	1.026	.77393
570.00	1.8107	12.916	207.70	29.118	208.91	2.1392	.29990	1.024	.78264
580.00	1.7996	12.837	213.21	29.891	214.45	2.1911	.30717	1.022	.79107
590.00	1.7889	12.760	218.75	30.667	220.03	2.2432	.31448	1.019	.79922
600.00	1.7786	12.687	224.33	31.449	225.63	2.2954	.32181	1.017	.80711
620.00	1.7591	12.547	235.57	33.025	236.94	2.4006	.33654	1.013	.82210
640.00	1.7409	12.418	246.93	34.619	248.37	2.5064	.35138	1.009	.83609
660.00	1.7240	12.298	258.42	36.228	259.91	2.6129	.36631	1.005	.84912
680.00	1.7083	12.185	270.00	37.853	271.57	2.7200	.38132	1.002	.86123
700.00	1.6936	12.080	281.70	39.492	283.33	2.8277	.39643	.9980	.87248
720.00	1.6798	11.982	293.49	41.145	295.19	2.9360	.41160	.9946	.88291
740.00	1.6669	11.890	305.38	42.812	307.14	3.0448	.42686	.9913	.89258
760.00	1.6549	11.804	317.35	44.491	319.18	3.1541	.44219	.9882	.90152
780.00	1.6435	11.723	329.41	46.182	331.31	3.2638	.45757	.9851	.90978
800.00	1.6329	11.647	341.56	47.894	343.52	3.3741	.47302	.9822	.91740
820.00	1.6229	11.576	353.78	49.597	355.81	3.4847	.48854	.9794	.92443
840.00	1.6135	11.509	366.07	51.320	368.17	3.5958	.50410	.9767	.93091
860.00	1.6046	11.446	378.43	53.054	380.60	3.7072	.51973	.9740	.93687
880.00	1.5963	11.386	390.87	54.797	393.10	3.8190	.53540	.9715	.94235
900.00	1.5884	11.330	403.36	56.549	405.67	3.9312	.55113	.9691	.94738
920.00	1.5810	11.277	415.93	58.310	418.30	4.0437	.56690	.9667	.95200
940.00	1.5740	11.227	428.56	60.081	430.99	4.1565	.58272	.9644	.95624
960.00	1.5674	11.180	441.25	61.860	443.75	4.2696	.59858	.9622	.96012
1000.00	1.5552	11.093	466.94	65.462	469.58	4.4968	.63042	.9576	.96692

THE ELECTRON DENSITY OF ZINC IS 2.765E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.068 BEV, AND THE MINIMUM ENERGY LOSS IS 1.4608 MEV/GM/CM2

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TABULATIONS (COMPOUNDS AND MIXTURES)

ALPHABETIC LIST OF MATERIALS

AIR  
BONE  
BRASS  
CALCIUM FLUORIDE  
CARBON DIOXIDE  
EMULSION (G-5)  
EMULSION (NTA)  
GLASS (PYREX)  
LEXAN  
LITHIUM FLUORIDE  
LUCITE  
METHANE  
MUSCLE  
NYLON  
POLYETHYLENE  
POLYSTYRENE  
SARAN  
SCINTILLATOR (ANTHRACENE)  
SCINTILLATOR (CS-1)  
SCINTILLATOR (NAI)  
SCINTILLATOR (PILOT B)  
SCINTILLATOR (STILBENE)  
SCINTILLATOR (TOLUNE)  
SILVER BROMIDE  
SILVER CHLORIDE  
STEEL (STAINLESS)  
TEFLON  
WATER

# AIR

PROTON ENERGY MEV	ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	V	7	5.3205	74.5287	14.007	86.70	.00505	.8442	0.
.15	O	8	1.4312	22.9009	15.999	88.90	.00659	.6051	0.
.20	A	18	.06434	2.5704	39.948	205.0	.00819	.5056	0.
.30							.01230	.4157	0.
.40							.01749	.3737	0.
.50							.02351	.3489	0.
.60							.03015	.3321	0.
.70							.03722	.3198	0.
.80							.04476	.3101	0.
.90							.05259	.3022	0.
1.00							.06066	.2954	0.
1.20							.07812	.2843	0.
1.40							.09723	.2754	0.
1.60							.11788	.2681	.00001
1.80							.14002	.2619	.00002
2.00							.16358	.2566	.00003
2.20							.18850	.2520	.00004
2.40							.21475	.2479	.00006
2.60							.24230	.2443	.00008
2.80							.27111	.2410	.00010
3.00							.30116	.2380	.00012
3.20							.33244	.2354	.00015
3.40							.36493	.2329	.00018
3.60							.39861	.2306	.00021
3.80							.43345	.2285	.00024
4.00							.46946	.2266	.00028
4.20							.50661	.2248	.00032
4.40							.54489	.2231	.00036
4.60							.58430	.2215	.00040
4.80							.62482	.2200	.00044

DENSITY = 1.2900 MG/CM3

# AIR

PRCTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON RANGE METER	PATH LENGTH GM/CM2	PATH LENGTH METER	GM/CM2	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	68.429	08.273	0.4206	0.4216	0.32679	0.0067	0.0517	1.581	0.0049
5.50	63.572	82.008	0.4964	0.4974	0.38560	0.0078	0.0601	1.559	0.0062
6.00	59.361	76.575	0.5777	0.5789	0.44880	0.0089	0.0691	1.539	0.0077
6.50	55.777	71.952	0.6645	0.6659	0.51619	0.0101	0.0786	1.522	0.0205
7.00	52.638	67.903	0.7566	0.7582	0.58773	0.0114	0.0885	1.506	0.0434
7.50	49.892	64.309	0.8540	0.8558	0.66340	0.0128	0.0990	1.492	0.0683
8.00	47.384	61.126	0.9566	0.9587	0.74319	0.0142	0.1100	1.480	0.0932
8.50	45.171	58.270	1.0647	1.0666	0.82699	0.0157	0.1214	1.468	0.1180
9.00	43.173	55.694	1.1777	1.1801	0.91482	0.0172	0.1333	1.457	0.1429
9.50	41.361	53.356	1.2953	1.2984	1.0065	0.0188	0.1457	1.447	0.1677
10.00	39.709	51.224	1.4190	1.4219	1.1022	0.0204	0.1585	1.438	0.1925
11.00	36.804	47.477	1.6303	1.6336	1.3051	0.0239	0.1855	1.421	0.2423
12.00	34.331	44.287	1.9613	1.9651	1.5234	0.0276	0.2142	1.406	0.2924
13.00	32.198	41.535	2.2617	2.2661	1.7567	0.0316	0.2447	1.393	0.3425
14.00	30.338	39.136	2.5813	2.5863	2.0049	0.0357	0.2769	1.381	0.3927
15.00	28.701	37.024	2.9197	2.9253	2.2677	0.0401	0.3108	1.370	0.4430
16.00	27.247	35.149	3.2768	3.2830	2.5450	0.0447	0.3463	1.361	0.4933
17.00	25.948	33.473	3.6524	3.6592	2.8366	0.0495	0.3834	1.352	0.5436
18.00	24.779	31.965	4.0462	4.0537	3.1424	0.0545	0.4221	1.343	0.5941
19.00	23.721	30.600	4.4581	4.4663	3.4622	0.0597	0.4624	1.336	0.6446
20.00	22.759	29.359	4.8878	4.8968	3.7960	0.0650	0.5043	1.328	0.6952
22.00	21.073	27.185	5.8003	5.8108	4.5045	0.0764	0.5925	1.315	0.7965
24.00	19.644	25.341	6.7823	6.7945	5.2671	0.0886	0.6867	1.304	0.8980
26.00	18.415	23.755	7.8327	7.8467	6.0827	0.1015	0.7867	1.293	0.9594
28.00	17.347	22.377	8.9504	8.9663	6.9506	0.1151	0.8924	1.284	0.9797
30.00	16.409	21.167	1.0134	1.0152	7.8700	0.1295	1.0036	1.275	1.0007
32.00	15.579	20.096	1.1384	1.1404	8.8401	0.1445	1.1203	1.267	1.0225
34.00	14.838	19.141	1.2697	1.2720	9.8602	0.1603	1.2423	1.260	1.0449
36.00	14.173	18.283	1.4075	1.4099	10.930	0.1767	1.3696	1.253	1.0680
38.00	13.572	17.508	1.5515	1.5542	12.048	0.1938	1.5019	1.247	1.0916
40.00	13.027	16.804	1.7017	1.7046	13.214	0.2115	1.6394	1.241	1.1157
45.00	11.860	15.299	2.1038	2.1074	16.337	0.2586	2.0046	1.227	1.1777
50.00	10.909	14.073	2.5431	2.5475	19.748	0.3095	2.3995	1.215	1.2418
55.00	10.120	13.054	3.0186	3.0237	23.440	0.3642	2.8231	1.204	1.3082
60.00	9.4526	12.194	3.5294	3.5353	27.406	0.4224	3.2743	1.195	1.3773
65.00	8.8813	11.457	4.0746	4.0814	31.639	0.4840	3.7522	1.186	1.4489
70.00	8.3861	10.818	4.6533	4.6610	36.132	0.5490	4.2559	1.178	1.5225
75.00	7.9528	10.259	5.2648	5.2736	40.880	0.6172	4.7845	1.170	1.5978
80.00	7.5701	9.7655	5.9085	5.9182	45.878	0.6885	5.3372	1.163	1.6745
90.00	6.9248	8.9330	7.2892	7.3012	56.598	0.8401	6.5123	1.151	1.8305

AIR

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH METER	GM/CM2	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	6.4013	8.7904	8.8047	68.254	.10031	.77757	1.139	.19884
110.00	5.9677	10.407	10.424	80.806	.11768	.91225	1.129	.21488
120.00	5.6027	12.135	12.155	94.222	.13607	1.0548	1.120	.23129
130.00	5.2910	13.970	13.992	108.29	.15543	1.2049	1.111	.24794
140.00	5.0217	15.908	15.933	123.51	.17570	1.3620	1.103	.26473
150.00	4.7866	17.945	17.974	139.33	.19684	1.5259	1.095	.28155
160.00	4.5797	20.078	20.111	155.90	.21881	1.6962	1.088	.29846
170.00	4.3961	22.304	22.340	173.18	.24158	1.8727	1.081	.31550
180.00	4.2321	24.620	24.659	191.16	.26509	2.0549	1.075	.33261
190.00	4.0848	27.022	27.065	209.80	.28932	2.2428	1.069	.34972
200.00	3.9517	29.508	29.554	229.10	.31423	2.4359	1.063	.36679
210.00	3.8309	32.074	32.125	249.03	.33980	2.6341	1.058	.38386
220.00	3.7208	34.719	34.774	269.57	.36600	2.8372	1.053	.40098
230.00	3.6200	37.440	37.499	290.24	.39280	3.0450	1.047	.41809
240.00	3.5274	40.235	40.298	312.39	.42017	3.2571	1.043	.43515
250.00	3.4420	43.101	43.169	334.64	.44809	3.4736	1.038	.45214
260.00	3.3631	46.036	46.108	357.43	.47654	3.6941	1.034	.46898
270.00	3.2900	49.038	49.115	380.73	.50550	3.9186	1.029	.48560
280.00	3.2220	52.105	52.187	404.55	.53494	4.1468	1.025	.50199
290.00	3.1587	55.235	55.321	428.85	.56484	4.3786	1.021	.51812
300.00	3.0995	58.426	58.518	453.63	.59520	4.6139	1.017	.53396
310.00	3.0442	61.677	61.774	478.86	.62598	4.8526	1.013	.54950
320.00	2.9923	64.986	65.087	504.55	.65718	5.0944	1.010	.56470
330.00	2.9436	68.350	68.457	530.67	.68878	5.3394	1.006	.57955
340.00	2.8977	71.769	71.881	557.22	.72076	5.5873	1.003	.59404
350.00	2.8545	75.241	75.358	584.17	.75311	5.8381	.9994	.60817
360.00	2.8137	78.765	78.887	611.53	.78582	6.0916	.9961	.62205
370.00	2.7752	82.338	82.466	639.27	.81886	6.3478	.9930	.63577
380.00	2.7387	85.960	86.093	667.39	.85224	6.6065	.9899	.64931
390.00	2.7042	89.629	89.768	695.88	.88594	6.8677	.9869	.66265
400.00	2.6714	93.345	93.489	724.72	.91994	7.1313	.9840	.67578
410.00	2.6402	97.105	97.254	753.91	.95424	7.3972	.9812	.68961
420.00	2.6106	100.91	101.06	783.44	.98883	7.6653	.9784	.70307
430.00	2.5824	104.75	104.92	813.30	1.0237	7.9356	.9757	.71616
440.00	2.5555	108.64	108.81	843.47	1.0588	8.2079	.9731	.72487
450.00	2.5299	112.57	112.74	873.96	1.0942	8.4822	.9705	.73622
460.00	2.5055	116.53	116.71	904.75	1.1298	8.7584	.9681	.74721
470.00	2.4821	120.54	120.72	935.84	1.1657	9.0366	.9656	.75783
480.00	2.4598	124.56	124.77	967.21	1.2018	9.3165	.9632	.76810
490.00	2.4384	128.66	128.85	998.86	1.2382	9.5982	.9609	.77802

# AIR

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GH/CH2	PROTON PATH LENGTH GH/CH2	PATH LENGTH STRAGGLING METER PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.4179	132.77	132.97	9.8816	.1526	.78759
510.00	2.3983	136.92	137.12	10.167	.1525	.79681
520.00	2.3795	141.10	141.31	10.453	.1523	.80571
530.00	2.3615	145.31	145.53	10.741	.1522	.81428
540.00	2.3441	149.55	149.78	11.031	.1520	.82253
550.00	2.3275	153.83	154.06	11.322	.1519	.83046
560.00	2.3115	158.13	158.37	11.615	.1518	.83809
570.00	2.2961	162.47	162.71	11.903	.1516	.84543
580.00	2.2813	166.83	167.08	12.204	.1515	.85247
590.00	2.2670	171.22	171.48	12.500	.1513	.85924
600.00	2.2533	175.64	175.90	12.798	.1512	.86573
620.00	2.2273	184.55	184.83	13.397	.1509	.87793
640.00	2.2031	193.57	193.86	14.001	.1506	.88914
660.00	2.1805	202.68	202.99	14.609	.1503	.89941
680.00	2.1594	211.89	212.21	15.221	.1500	.90882
700.00	2.1397	221.16	221.51	15.837	.1497	.91742
720.00	2.1213	230.55	230.90	16.456	.1495	.92527
740.00	2.1040	240.01	240.37	17.080	.1492	.93243
760.00	2.0878	249.54	249.91	17.706	.1489	.93895
780.00	2.0726	259.14	259.52	18.336	.1486	.94488
800.00	2.0582	268.81	269.21	18.969	.1483	.95027
820.00	2.0447	278.54	278.96	19.604	.1480	.95516
840.00	2.0320	288.34	288.77	20.243	.1477	.95959
860.00	2.0200	298.20	298.64	20.884	.1475	.96361
880.00	2.0087	308.12	308.58	21.528	.1472	.96724
900.00	1.9980	318.10	318.56	22.174	.1469	.97053
920.00	1.9879	328.12	328.61	22.822	.1466	.97350
940.00	1.9783	338.21	338.70	23.473	.1463	.97618
960.00	1.9693	348.35	348.86	24.126	.1460	.97861
1000.00	1.9526	368.85	369.38	25.436	.1451	.98278

THE ELECTRON DENSITY OF AIR IS 3.004E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.272 BEV, AND THE MINIMUM ENERGY LOSS IS 1.8083 MEV/GH/CH2

THE EFFECTIVE IONIZATION POTENTIAL IS 88.96 ELECTRON VOLTS



[illegible]

DENSITY = 1.8500 GM/CH3

## BONE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PATH LENGTH GM/CM2		PATH LENGTH STRAGGLING GM/CM2		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
5.00	72.960	.03929	.02124	.03939	.02129	.00072	.00039	.2376	.00036
5.50	67.773	.04639	.02508	.04650	.02514	.00083	.00045	.2347	.00046
6.00	63.336	.05401	.02920	.05414	.02927	.00096	.00052	.2321	.00108
6.50	59.496	.06215	.03359	.06229	.03367	.00109	.00059	.2298	.00198
7.00	56.137	.07078	.03826	.07095	.03835	.00122	.00066	.2278	.00340
7.50	53.148	.07992	.04320	.08010	.04330	.00135	.00074	.2259	.00516
8.00	50.512	.08936	.04841	.08976	.04852	.00151	.00082	.2242	.00595
8.50	48.148	.09947	.05388	.09990	.05400	.00167	.00090	.2226	.00875
9.00	46.018	.11028	.05961	.11052	.05974	.00183	.00099	.2212	.01056
9.50	44.084	.12136	.06580	.12163	.06575	.00199	.00108	.2199	.01237
10.00	42.320	.13292	.07185	.13321	.07200	.00217	.00117	.2187	.01419
11.00	39.221	.15743	.08510	.15777	.08528	.00253	.00137	.2164	.01790
12.00	36.584	.18380	.09935	.18419	.09956	.00292	.00158	.2145	.02164
13.00	34.309	.21198	.11458	.21243	.11483	.00333	.00180	.2128	.02565
14.00	32.327	.24196	.13079	.24248	.13107	.00376	.00203	.2112	.02967
15.00	30.581	.27372	.14795	.27429	.14827	.00421	.00228	.2098	.03370
16.00	29.032	.30726	.16607	.30786	.16641	.00469	.00253	.2085	.03773
17.00	27.648	.34246	.18511	.34317	.18550	.00518	.00280	.2074	.04179
18.00	26.402	.37941	.20509	.38020	.20551	.00570	.00308	.2063	.04585
19.00	25.275	.41806	.22595	.41892	.22644	.00624	.00337	.2053	.04992
20.00	24.250	.45838	.24777	.45932	.24828	.00679	.00367	.2044	.05401
22.00	22.454	.54400	.29405	.54510	.29465	.00797	.00431	.2028	.06221
24.00	20.931	.63614	.34386	.63743	.34455	.00922	.00498	.2013	.07044
26.00	19.622	.73470	.39713	.73617	.39793	.01055	.00570	.2001	.07547
28.00	18.484	.83957	.45382	.84124	.45473	.01195	.00646	.1989	.07717
30.00	17.485	.95066	.51387	.95255	.51489	.01342	.00726	.1979	.07895
32.00	16.600	1.0679	.57724	1.0700	.57837	.01497	.00809	.1970	.08078
34.00	15.821	1.1911	.64386	1.1935	.64513	.01658	.00896	.1961	.08267
36.00	15.102	1.3204	.71371	1.3230	.71511	.01825	.00987	.1954	.08462
38.00	14.462	1.4555	.78675	1.4583	.78828	.02001	.01082	.1946	.08661
40.00	13.881	1.5964	.86292	1.5995	.86460	.02183	.01180	.1940	.08865
45.00	12.638	1.9737	1.0669	1.9775	1.0689	.02664	.01440	.1925	.09391
50.00	11.625	2.3859	1.2897	2.3905	1.2921	.03185	.01721	.1913	.09935
55.00	10.784	2.8320	1.5308	2.8374	1.5337	.03742	.02023	.1902	.10501
60.00	10.073	3.3112	1.7899	3.3175	1.7932	.04336	.02344	.1893	.11092
65.00	9.4641	3.8227	2.0663	3.8279	2.0702	.04964	.02683	.1885	.11706
70.00	8.9365	4.3657	2.3598	4.3739	2.3643	.05625	.03041	.1878	.12340
75.00	8.4749	4.9394	2.6700	4.9487	2.6750	.06319	.03416	.1871	.12990
80.00	8.0671	5.5433	3.0964	5.5536	3.0920	.07044	.03808	.1865	.13555
90.00	7.3794	6.8387	3.6966	6.8514	3.7035	.08585	.04641	.1853	.15017

## BONE

PROTON ENERGY MEV	ENERGY LOSS MEV/GM/CM <sup>2</sup>	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH GM/CM <sup>2</sup>	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM <sup>2</sup>	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	6.8214	8.2471	8.2823	4.4661	.10240	.05535	1.239	.16406
110.00	6.3594	9.7839	9.7839	5.2875	.12004	.06489	1.227	.17629
120.00	5.9703	11.385	11.406	6.1634	.13869	.07497	1.216	.19293
130.00	5.6381	13.107	13.131	7.0976	.15832	.08558	1.206	.20791
140.00	5.3511	14.925	14.952	8.0822	.17887	.09660	1.196	.22311
150.00	5.1004	16.836	16.867	9.1173	.20028	.10826	1.187	.23846
160.00	4.8798	18.838	18.872	10.201	.22253	.12029	1.179	.25396
170.00	4.6841	20.927	20.965	11.332	.24557	.13274	1.171	.26963
180.00	4.5093	23.099	23.141	12.509	.26937	.14561	1.164	.28541
190.00	4.3522	25.353	25.399	13.729	.29389	.15886	1.157	.30123
200.00	4.2102	27.686	27.736	14.992	.31909	.17248	1.150	.31707
210.00	4.0814	30.094	30.148	16.296	.34495	.18646	1.144	.33289
220.00	3.9640	32.577	32.635	17.641	.37143	.20077	1.138	.34871
230.00	3.8564	35.130	35.193	19.023	.39852	.21542	1.132	.36447
240.00	3.7577	37.753	37.820	20.444	.42618	.23037	1.127	.38014
250.00	3.6666	40.443	40.515	21.900	.45439	.24562	1.122	.39570
260.00	3.5825	43.197	43.274	23.392	.48313	.26115	1.116	.41116
270.00	3.5044	46.015	46.097	24.917	.51238	.27696	1.112	.42650
280.00	3.4319	48.894	48.981	26.476	.54211	.29303	1.107	.44173
290.00	3.3643	51.832	51.924	28.067	.57231	.30936	1.102	.45680
300.00	3.3012	54.828	54.925	29.689	.60295	.32592	1.098	.47170
310.00	3.2421	57.879	57.982	31.342	.63403	.34272	1.093	.48652
320.00	3.1868	60.985	61.093	33.023	.66592	.35974	1.089	.50119
330.00	3.1347	64.144	64.257	34.734	.69741	.37698	1.085	.51571
340.00	3.0858	67.354	67.473	36.472	.72958	.39442	1.081	.53006
350.00	3.0397	70.613	70.735	38.237	.76231	.41206	1.078	.54422
360.00	2.9961	73.921	74.052	40.028	.79531	.42990	1.074	.55823
370.00	2.9550	77.277	77.413	41.845	.82864	.44791	1.070	.57215
380.00	2.9160	80.678	80.820	43.687	.86230	.46611	1.067	.58595
390.00	2.8791	84.123	84.272	45.552	.89629	.48448	1.064	.59960
400.00	2.8440	87.612	87.766	47.441	.93057	.50301	1.060	.61310
410.00	2.8108	91.143	91.303	49.333	.96515	.52171	1.057	.62636
420.00	2.7791	94.715	94.882	51.287	1.00000	.54055	1.054	.63932
430.00	2.7490	98.327	98.500	53.243	1.0352	.55955	1.051	.65197
440.00	2.7203	101.98	102.16	55.220	1.0706	.57869	1.048	.66430
450.00	2.6929	105.67	105.85	57.217	1.1062	.59797	1.045	.67632
460.00	2.6667	109.39	109.58	59.234	1.1422	.61738	1.042	.68803
470.00	2.6417	113.15	113.35	61.271	1.1783	.63692	1.040	.69941
480.00	2.6178	116.95	117.15	63.326	1.2147	.65659	1.037	.71049
490.00	2.5950	120.78	120.99	65.400	1.2513	.67638	1.034	.72125

## BONE

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	PERCENT		
500.00	2.5731	4.7602	124.64	67.375	124.86	67.492	1.2861	1.032	.1745	.73170
510.00	2.5521	4.7214	128.54	69.480	128.76	69.602	1.3252	1.029	.1744	.74185
520.00	2.5320	4.6841	132.47	71.603	132.70	71.728	1.3624	1.027	.1742	.75171
530.00	2.5126	4.6484	136.42	73.743	136.66	73.871	1.3999	1.024	.1741	.76127
540.00	2.4941	4.6140	140.41	75.898	140.66	76.031	1.4375	1.022	.1739	.77055
550.00	2.4762	4.5810	144.43	78.070	144.68	78.206	1.4753	1.020	.1738	.77954
560.00	2.4591	4.5493	148.48	80.257	148.73	80.396	1.5133	1.017	.1736	.78825
570.00	2.4426	4.5188	152.55	82.459	152.81	82.602	1.5515	1.015	.1735	.79668
580.00	2.4267	4.4894	156.65	84.675	156.92	84.822	1.5898	1.013	.1733	.80484
590.00	2.4114	4.4612	160.78	86.906	161.05	87.057	1.6283	1.011	.1732	.81273
600.00	2.3967	4.4339	164.93	89.151	165.21	89.305	1.6670	1.009	.1731	.82036
620.00	2.3688	4.3823	173.31	93.843	173.61	93.843	1.7443	1.005	.1728	.83485
640.00	2.3428	4.3342	181.79	98.432	182.10	98.432	1.8232	1.001	.1725	.84837
660.00	2.3185	4.2894	190.35	102.89	190.68	103.07	1.9021	0.997	.1722	.86096
680.00	2.2960	4.2476	199.01	107.57	199.35	107.76	1.9816	0.994	.1719	.87266
700.00	2.2749	4.2084	207.74	112.29	208.10	112.49	2.0616	0.990	.1716	.88351
720.00	2.2550	4.1717	216.56	117.06	216.93	117.26	2.1420	0.987	.1713	.89356
740.00	2.2364	4.1373	225.45	121.87	225.84	122.08	2.2229	0.983	.1710	.90285
760.00	2.2182	4.1050	234.42	126.71	234.82	126.93	2.3043	0.981	.1707	.91142
780.00	2.2025	4.0746	243.45	131.59	243.87	131.82	2.3860	0.978	.1705	.91930
800.00	2.1870	4.0460	252.55	136.51	252.98	136.75	2.4681	0.975	.1702	.92654
820.00	2.1725	4.0191	261.71	141.46	262.16	141.71	2.5506	0.972	.1699	.93317
840.00	2.1588	3.9937	270.93	146.45	271.39	146.70	2.6335	0.970	.1696	.93925
860.00	2.1458	3.9697	280.21	151.47	280.69	151.72	2.7166	0.967	.1693	.94481
880.00	2.1336	3.9471	289.55	156.51	290.04	156.78	2.8002	0.965	.1690	.94990
900.00	2.1220	3.9257	298.93	161.59	299.44	161.86	2.8840	0.963	.1687	.95455
920.00	2.1110	3.9054	308.38	166.69	308.90	166.97	2.9681	0.961	.1684	.95878
940.00	2.1007	3.8862	317.87	171.82	318.40	172.11	3.0525	0.958	.1681	.96265
960.00	2.0908	3.8681	327.42	176.98	327.97	177.28	3.1372	0.956	.1677	.96618
1000.00	2.0727	3.8345	346.72	187.42	347.30	187.73	3.3074	0.952	.1668	.97233

THE ELECTRON DENSITY OF BONE IS 3.194E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.278 BEV, AND THE MINIMUM ENERGY LOSS IS 1.9021 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 87.35 ELECTRON VOLTS

## BRASS

PROTON ENERGY MEV	ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL	PROTON RANGE		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION			
							MG/CM2	MM	MG/CM2	MM					
.10	CU	29	.9879	61.4999	63.540	320.0	.53270	.00063	.54636	.00064	.02641	.00003	4.834	2.500	0.
.15							.75286	.00089	.76806	.00090	.03497	.00004	4.554	1.979	0.
.20							.97582	.00115	.99402	.00117	.04197	.00005	4.222	1.831	0.
.30	ZN	30	.5392	35.2472	65.370	330.9	1.4531	.00171	1.4787	.00174	.05517	.00006	3.731	1.734	0.
.40	PB	82	.6157	3.2529	207.19	810.0	1.9825	.00234	2.0165	.00238	.06898	.00008	3.421	1.683	0.
.50							2.5635	.00302	2.6063	.00307	.08355	.00010	3.207	1.640	0.
.60							3.1953	.00376	3.2478	.00383	.09972	.00012	3.070	1.598	0.
.70							3.8788	.00457	3.9402	.00464	.11728	.00014	2.977	1.559	0.
.80							4.6077	.00543	4.6789	.00551	.13580	.00016	2.902	1.522	0.
.90							5.3761	.00634	5.4593	.00643	.15496	.00018	2.838	1.488	0.
1.00							6.1869	.00729	6.2803	.00740	.17460	.00021	2.780	1.455	0.
1.20							7.9437	.00936	8.0563	.00949	.21617	.00025	2.683	1.397	0.
1.40							9.8778	.01164	10.013	.01179	.26064	.00031	2.603	1.347	0.
1.60							11.985	.01412	12.143	.01430	.30790	.00036	2.536	1.303	0.
1.80							14.258	.01680	14.441	.01701	.35780	.00042	2.478	1.265	0.
2.00							16.689	.01966	16.897	.01990	.41004	.00048	2.427	1.231	0.
2.20							19.273	.02270	19.508	.02298	.46444	.00055	2.381	1.202	0.
2.40							22.009	.02593	22.271	.02624	.52087	.00061	2.339	1.175	0.
2.60							24.991	.02932	25.181	.02966	.57924	.00068	2.300	1.152	0.
2.80							27.917	.03289	28.236	.03326	.63948	.00075	2.265	1.130	0.
3.00							31.086	.03662	31.435	.03703	.73153	.00083	2.232	1.111	0.
3.20							34.387	.04051	34.767	.04096	.76529	.00090	2.201	1.093	0.
3.40							37.829	.04456	38.241	.04505	.83080	.00098	2.173	1.077	0.
3.60							41.404	.04877	41.848	.04930	.89806	.00106	2.146	1.062	0.
3.80							45.110	.05314	45.587	.05370	.96702	.00114	2.121	1.048	0.
4.00							48.946	.05766	49.458	.05826	1.0377	.00122	2.098	1.033	0.
4.20							52.917	.06234	53.464	.06298	1.1100	.00131	2.076	1.023	.00001
4.40							57.011	.06716	57.593	.06784	1.1843	.00140	2.056	1.012	.00001
4.60							61.236	.07214	61.855	.07286	1.2604	.00148	2.038	1.001	.00001
4.80							65.586	.07736	66.243	.07803	1.3385	.00158	2.021	.9912	.00001

## BRASS

PROTON ENERGY MEV.	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM2	MEV/CM	GM/CM2	CH	GM/CM2	CH	GM/CM2	CH		
5.00	43.706	371.02	.07006	.00825	.07076	.00834	.00142	.00017	2.005	.00002
5.30	40.936	347.50	.08179	.05963	.08258	.00973	.00163	.00019	1.970	.00003
6.00	38.536	327.13	.10428	.09428	.09518	.01121	.00185	.00022	1.940	.00005
6.50	36.435	309.30	.10753	.09267	.10853	.01278	.00208	.00024	1.913	.00007
7.00	34.582	293.57	.12150	.09131	.12262	.01444	.00232	.00027	1.889	.00010
7.50	32.933	279.57	.13621	.09105	.13744	.01619	.00257	.00030	1.868	.00014
8.00	31.456	267.03	.15163	.09186	.15298	.01802	.00283	.00033	1.848	.00018
8.50	30.120	255.69	.16775	.09176	.16923	.01994	.00310	.00036	1.830	.00023
9.00	28.911	245.43	.18457	.092174	.18618	.02193	.00338	.00040	1.813	.00029
9.50	27.798	235.98	.20207	.09360	.20382	.02401	.00366	.00043	1.798	.00036
10.00	26.777	227.31	.22027	.02595	.22215	.02617	.00396	.00047	1.783	.00043
11.00	24.975	212.01	.25867	.03047	.26084	.03073	.00458	.00054	1.756	.00059
12.00	23.441	198.59	.29972	.03531	.30219	.03560	.00524	.00062	1.732	.00079
13.00	22.108	187.68	.34335	.04045	.34614	.04078	.00592	.00070	1.711	.00112
14.00	20.936	177.73	.38952	.04589	.39265	.04625	.00664	.00078	1.691	.00149
15.00	19.896	168.90	.43819	.05162	.44167	.05203	.00739	.00087	1.672	.00223
16.00	18.967	161.01	.48933	.05764	.49317	.05810	.00816	.00096	1.655	.00451
17.00	18.130	153.90	.54288	.06395	.54710	.06445	.00897	.00106	1.640	.00683
18.00	17.372	147.47	.59885	.07054	.60346	.07109	.00981	.00116	1.625	.00917
19.00	16.682	141.62	.65720	.07742	.66222	.07801	.01068	.00126	1.612	.01153
20.00	16.052	136.27	.71768	.08457	.72333	.08521	.01157	.00136	1.600	.01390
22.00	14.941	126.83	.84626	.09969	.85259	.10043	.01344	.00158	1.577	.01871
24.00	13.991	118.77	.98374	.11588	.99101	.11674	.01542	.00182	1.556	.02359
26.00	13.169	111.79	1.1302	.13313	1.1384	.13411	.01751	.00206	1.538	.02884
28.00	12.451	105.69	1.2852	.15142	1.2947	.15251	.01970	.00232	1.522	.02841
30.00	11.817	100.31	1.4492	.17072	1.4596	.17194	.02199	.00259	1.507	.03004
32.00	11.252	95.520	1.6216	.19103	1.6332	.19239	.02438	.00287	1.493	.03174
34.00	10.747	91.231	1.8024	.21232	1.8151	.21382	.02687	.00317	1.480	.03350
36.00	10.291	87.364	1.9913	.23458	2.0053	.23622	.02945	.00347	1.469	.03532
38.00	9.8791	83.863	2.1885	.25780	2.2037	.25960	.03212	.00378	1.458	.03719
40.00	9.5026	80.670	2.3936	.28196	2.4102	.28392	.03489	.00411	1.447	.03911
45.00	8.6935	73.799	2.9408	.34643	2.9610	.34880	.04218	.00497	1.425	.04413
50.00	8.0297	68.164	3.5361	.41655	3.5600	.41937	.05001	.00589	1.405	.04942
55.00	7.4754	63.459	4.1779	.49215	4.2059	.49545	.05835	.00687	1.387	.05496
60.00	7.0048	59.464	4.8649	.57309	4.8973	.57690	.06719	.00791	1.372	.06079
65.00	6.6002	56.029	5.5961	.65922	5.6331	.66357	.07650	.00901	1.358	.06686
70.00	6.2479	53.039	6.3762	.75041	6.4120	.75534	.08626	.01016	1.345	.07316
75.00	5.9385	50.412	7.1664	.84655	7.2333	.85202	.09647	.01136	1.334	.07967
80.00	5.5832	47.395	8.0530	.94864	8.1052	.95479	.10734	.01264	1.324	.08640
90.00	5.0923	45.229	9.9148	1.1660	9.9783	1.1754	.13101	.01543	1.313	.10051

## BRASS

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE		PATH LENGTH GM/CM2		PATH LENGTH STRAGGLING GM/CM2		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CH	GM/CM2	CH	GM/CM2	CH		
100.00	4.7313	11.944	1.4070	12.019	1.4159	15613	1.0839	.6285	.11510
110.00	4.4306	14.101	1.6611	14.190	1.5716	18253	1.4150	.6274	.13014
120.00	4.1755	16.401	1.9320	16.504	1.9442	21018	1.2476	.6260	.14561
130.00	3.9560	18.843	2.2196	18.961	2.2336	23905	1.02616	.6247	.16144
140.00	3.7656	21.431	2.5246	21.565	2.5404	26908	1.03170	.6199	.17753
150.00	3.5989	24.126	2.8421	24.277	2.8598	30022	1.03537	.6212	.19379
160.00	3.4514	26.942	3.1738	27.110	3.1936	33244	1.03916	.6191	.21027
170.00	3.3201	29.871	3.5108	30.057	3.5407	36567	1.04308	.6196	.22699
180.00	3.2024	32.913	3.8771	33.118	3.9012	39988	1.04711	.6180	.24389
190.00	3.0964	36.081	4.2503	36.305	4.2767	43502	1.05124	.6168	.26093
200.00	3.0004	39.329	4.6330	39.573	4.6617	47105	1.05547	.6153	.27805
210.00	2.9130	42.692	5.0291	42.956	5.0602	50793	1.05983	.6142	.29524
220.00	2.8332	46.140	5.4353	46.424	5.4688	54562	1.06427	.6130	.31247
230.00	2.7768	49.662	5.8501	49.968	5.8862	58372	1.06876	.6126	.32966
240.00	2.7027	53.270	6.2752	53.598	6.3138	62255	1.07354	.6116	.34681
250.00	2.6400	57.007	6.7153	57.358	6.7567	66213	1.07800	.6124	.36391
260.00	2.5818	60.800	7.1622	61.174	7.2063	70242	1.08275	.6119	.38089
270.00	2.5279	64.705	7.6222	65.103	7.6691	74339	1.08757	.6112	.39773
280.00	2.4778	68.678	8.0982	69.100	8.1399	78502	1.09247	.6104	.41439
290.00	2.4310	72.728	8.5974	73.175	8.6200	82726	1.09745	.6105	.43085
300.00	2.3873	76.865	9.0547	77.337	9.1103	87009	1.10250	.6099	.44709
310.00	2.3464	81.076	9.5507	81.573	9.6093	91350	1.10761	.6093	.46312
320.00	2.3080	85.315	10.050	85.839	10.112	95745	1.11279	.6095	.47895
330.00	2.2705	89.657	10.562	90.206	10.626	1.0020	1.1804	.6089	.49458
340.00	2.2366	93.998	11.073	94.574	11.141	1.0472	1.2336	.6084	.50998
350.00	2.2046	98.437	11.596	99.039	11.667	1.0929	1.2874	.6076	.52514
360.00	2.1744	102.98	12.131	103.61	12.205	1.1390	1.3418	.6071	.54035
370.00	2.1459	107.59	12.675	108.25	12.752	1.1856	1.3966	.6068	.55470
380.00	2.1189	112.25	13.223	112.94	13.304	1.2326	1.4520	.6062	.56908
390.00	2.0932	116.97	13.779	117.68	13.863	1.2800	1.5078	.6056	.58318
400.00	2.0689	121.78	14.345	122.52	14.433	1.3277	1.5641	.6043	.59699
410.00	2.0459	126.61	14.914	127.37	15.005	1.3759	1.6208	.6039	.61051
420.00	2.0239	131.49	15.489	132.28	15.583	1.4244	1.6779	.6033	.62372
430.00	2.0030	136.42	16.070	137.25	16.168	1.4733	1.7355	.6028	.63663
440.00	1.9831	141.41	16.657	142.26	16.758	1.5225	1.7935	.6022	.64923
450.00	1.9641	146.44	17.250	147.32	17.355	1.5720	1.8518	.6018	.66151
460.00	1.9460	151.52	17.849	152.44	17.957	1.6218	1.9105	.6014	.67348
470.00	1.9286	156.65	18.453	157.59	18.564	1.6720	1.9696	.6009	.68514
480.00	1.9121	161.88	19.046	162.66	19.162	1.7224	2.0290	.6014	.69649
490.00	1.8962	166.90	19.660	167.91	19.779	1.7731	2.0887	.6010	.70752

## BRASS

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CH2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.8811	15.968	172.15	20.279	173.19	20.402	1.8241	.71824
510.00	1.8665	15.845	177.45	20.904	178.32	21.030	1.8753	.72866
520.00	1.8526	15.727	182.79	21.533	183.89	21.662	1.9268	.73877
530.00	1.8392	15.613	188.17	22.166	189.30	22.299	1.9786	.74859
540.00	1.8264	15.504	193.59	22.804	194.75	22.941	2.0305	.75810
550.00	1.8141	15.400	199.04	23.447	200.23	23.587	2.0827	.76732
560.00	1.8022	15.299	204.53	24.093	205.75	24.238	2.1352	.77626
570.00	1.7908	15.202	210.05	24.744	211.31	24.892	2.1878	.78491
580.00	1.7799	15.109	215.61	25.399	216.90	25.551	2.2407	.79328
590.00	1.7693	15.020	221.21	26.059	222.54	26.215	2.2937	.80138
600.00	1.7592	14.934	226.84	26.721	228.20	26.882	2.3470	.80921
620.00	1.7400	14.770	238.18	28.058	239.51	28.226	2.4540	.82408
640.00	1.7221	14.619	249.07	29.446	251.46	29.622	2.5618	.83796
660.00	1.7054	14.478	261.56	30.812	263.12	30.996	2.6702	.85087
680.00	1.6899	14.346	273.27	32.191	274.90	32.384	2.7793	.86286
700.00	1.6754	14.223	285.08	33.582	286.78	33.782	2.8889	.87403
720.00	1.6619	14.108	296.99	34.985	298.76	35.193	2.9992	.88433
740.00	1.6492	14.000	308.89	36.398	310.82	36.615	3.1099	.89393
760.00	1.6373	13.899	321.07	37.822	322.98	38.047	3.2212	.90278
780.00	1.6262	13.805	333.24	39.256	335.22	39.489	3.3329	.91095
800.00	1.6157	13.716	345.50	40.700	347.55	40.941	3.4451	.91849
820.00	1.6058	13.632	357.83	42.152	359.95	42.402	3.5577	.92545
840.00	1.5966	13.553	370.24	43.614	372.43	43.872	3.6707	.93185
860.00	1.5879	13.478	382.73	45.085	384.99	45.352	3.7841	.93774
880.00	1.5796	13.410	395.26	46.562	397.60	46.838	3.8978	.94316
900.00	1.5719	13.344	407.89	48.050	410.31	48.334	4.0119	.94813
920.00	1.5646	13.282	420.60	49.547	423.09	49.840	4.1264	.95269
940.00	1.5577	13.223	433.37	51.050	435.94	51.353	4.2412	.95688
960.00	1.5512	13.168	446.20	52.552	448.85	52.875	4.3562	.96071
1000.00	1.5392	13.066	472.19	55.023	475.01	55.956	4.5872	.96742

THE ELECTRON DENSITY OF BRASS IS 2.743E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.067 BEV, AND THE MINIMUM ENERGY LOSS IS 1.4440 MEV/GM/CH2

THE EFFECTIVE IONIZATION POTENTIAL IS 332.45 ELECTRON VOLTS



# CALCIUM FLUORIDE

PROTON ENERGY MEV	ELEMENT CA F	ATOMIC NUMBER 20 9	ATOMS/ MOLECULE 1 2	PERCENT BY WEIGHT 51.3341 48.6659	ATOMIC HEIGHT 40.080 18.998	ADJUSTED IONIZATION POTENTIAL 211.3 120.7	DENSITY = 3.1800 GM/CM3										
							PROTON RANGE		PATH LENGTH		PROTON LENGTH		PATH LENGTH		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
							GH/CM2	MM	MG/CM2	MM	MM	MM	MM	PERCENT			
.10							.26885	.00085	.01249	.00004	4.585	1.294	0.				
.15							.36579	.00115	.01406	.00004	3.804	1.016	0.				
.20							.47406	.00149	.01601	.00005	3.347	.8872	0.				
.30							.72671	.00229	.02133	.00007	2.913	.7639	0.				
.40							1.0314	.00324	.02850	.00009	2.744	.7019	0.				
.50							1.3861	.00436	.03719	.00012	2.665	.6637	0.				
.60							1.7809	.00560	.04645	.00015	2.592	.6367	0.				
.70							2.1210	.00693	.05627	.00018	2.528	.6161	0.				
.80							2.6876	.00845	.06756	.00021	2.499	.6001	0.				
.90							3.2003	.01006	.07917	.00025	2.439	.5859	0.				
1.00							3.7509	.01180	.09078	.00029	2.406	.5726	0.				
1.20							4.9044	.01561	.11531	.00036	2.310	.5502	0.				
1.40							6.3172	.01987	.14169	.00045	2.231	.5325	0.				
1.60							7.8034	.02467	.16978	.00053	2.164	.5181	0.				
1.80							9.4182	.02977	.19951	.00063	2.108	.5059	.00001				
2.00							11.158	.03509	.23096	.00073	2.060	.4954	.00001				
2.20							13.054	.04114	.26432	.00083	2.020	.4863	.00002				
2.40							15.004	.04718	.29951	.00094	1.987	.4782	.00002				
2.60							17.106	.05405	.33644	.00106	1.958	.4710	.00003				
2.80							19.324	.06105	.37502	.00118	1.932	.4645	.00004				
3.00							21.756	.06841	.41513	.00131	1.908	.4586	.00005				
3.20							24.211	.07614	.45688	.00144	1.887	.4532	.00006				
3.40							26.778	.08421	.50006	.00157	1.867	.4482	.00008				
3.60							29.325	.09222	.54469	.00171	1.849	.4437	.00009				
3.80							32.100	.10094	.59077	.00186	1.832	.4394	.00011				
4.00							34.983	.11001	.63826	.00201	1.817	.4353	.00013				
4.20							37.974	.11942	.68715	.00216	1.802	.4316	.00014				
4.40							41.069	.12970	.73740	.00232	1.788	.4284	.00017				
4.60							44.270	.13921	.78906	.00248	1.775	.4252	.00019				
4.80							47.576	.14961	.84197	.00265	1.762	.4222	.00021				

# CALCIUM FLUORIDE

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH CH		GM/CH2	PATH LENGTH STRAGGLING CH		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
			GM/CH2	CH		GM/CH2	PERCENT		
5.00	57.641	133.30	.05119	.01610	.00090	.00028	1.750	.4193	.00024
5.50	53.736	170.68	.06019	.01893	.00104	.00033	1.723	.4128	.00031
6.00	50.377	160.20	.06980	.02195	.00119	.00037	1.655	.4070	.00039
6.50	47.456	150.91	.07971	.02507	.00134	.00042	1.677	.4019	.00049
7.00	44.809	142.75	.09051	.02846	.00151	.00047	1.657	.3973	.00060
7.50	42.613	135.51	.10231	.03217	.00168	.00053	1.639	.3912	.00060
8.00	40.580	129.04	.11433	.03595	.00185	.00058	1.622	.394	.00078
8.50	38.751	123.23	.12695	.03992	.00204	.00064	1.607	.3859	.00096
9.00	37.097	117.97	.14014	.04407	.00223	.00070	1.593	.3827	.00115
9.50	35.576	113.13	.15390	.04840	.00243	.00076	1.580	.3798	.00134
10.00	34.204	108.77	.16824	.05290	.00264	.00083	1.568	.3770	.00154
11.00	31.785	101.06	.19860	.06245	.00307	.00097	1.546	.3721	.00195
12.00	29.718	94.503	.23115	.07269	.00353	.00111	1.527	.3678	.01245
13.00	27.929	88.814	.26588	.08361	.00401	.00126	1.510	.3640	.01608
14.00	26.365	83.839	.30275	.09521	.00452	.00142	1.494	.3606	.01972
15.00	24.984	79.449	.34273	.10746	.00506	.00159	1.481	.3576	.02338
16.00	23.755	75.542	.38279	.12037	.00562	.00177	1.468	.3548	.02705
17.00	22.655	72.042	.42591	.13393	.00620	.00195	1.455	.3522	.03074
18.00	21.663	68.887	.47107	.14813	.00681	.00214	1.443	.3499	.03444
19.00	20.763	66.025	.51823	.16297	.00744	.00234	1.435	.3478	.03815
20.00	19.943	63.419	.56739	.17842	.00809	.00254	1.426	.3458	.04188
22.00	18.504	58.843	.67158	.21119	.00946	.00298	1.409	.3423	.04938
24.00	17.280	54.950	.78351	.24639	.01092	.00343	1.394	.3392	.05694
26.00	16.225	51.595	.90302	.28397	.01247	.00392	1.380	.3365	.06467
28.00	15.306	48.672	1.03000	.32390	.01409	.00443	1.368	.3340	.07247
30.00	14.497	46.100	1.16443	.36514	.01580	.00497	1.357	.3318	.08035
32.00	13.780	43.819	1.3059	.40866	.01759	.00553	1.347	.3299	.08829
34.00	13.139	41.781	1.4498	.45741	.01946	.00612	1.338	.3281	.09630
36.00	12.562	39.848	1.6050	.50636	.02140	.00673	1.329	.3264	.10437
38.00	12.041	38.290	1.7672	.55754	.02342	.00737	1.321	.3249	.11250
40.00	11.567	36.782	1.9362	.61084	.02552	.00802	1.314	.3236	.12082
45.00	10.550	33.550	2.3957	.75336	.03107	.00977	1.297	.3205	.13151
50.00	9.7198	30.909	2.8808	.90879	.03705	.01165	1.282	.3179	.14156
55.00	9.0290	28.712	3.4133	1.0734	.04345	.01366	1.269	.3158	.15200
60.00	8.4442	26.853	3.9971	1.2570	.05026	.01580	1.257	.3139	.16355
65.00	7.9424	25.257	4.5937	1.4491	.05745	.01807	1.247	.3122	.17570
70.00	7.5070	23.872	5.2359	1.6528	.06502	.02045	1.237	.3107	.18822
75.00	7.1258	22.660	5.9398	1.8679	.07295	.02294	1.228	.3094	.20177
80.00	6.7883	21.587	6.6385	2.0940	.08123	.02554	1.220	.3082	.21648
90.00	6.2183	19.774	8.2002	2.5787	.09861	.03107	1.203	.3062	.24228

# CALCIUM FLUORIDE

PROTON ENERGY MeV	ENERGY LOSS HEV/CH	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	CH	PATH LENGTH STRAGGLING GM/CM2	CH	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	5.7550	18.301	9.8434	3.0954	11766	.03700	1.192	.3043	.15742
110.00	5.3707	17.079	11.638	3.6599	13773	.04331	1.180	.3030	.17293
120.00	5.0468	16.049	13.955	4.2625	15894	.04998	1.169	.3018	.18890
130.00	4.7698	15.166	15.588	4.9019	18123	.05699	1.159	.3007	.20521
140.00	4.5304	14.407	17.734	5.5768	20454	.06432	1.150	.2997	.22177
150.00	4.3212	13.741	19.989	6.2857	22884	.07165	1.141	.2988	.23849
160.00	4.1362	13.155	22.348	7.0276	25406	.07989	1.132	.2981	.25536
170.00	3.9732	12.635	24.808	7.8012	28016	.08810	1.124	.2974	.27240
180.00	3.8270	12.170	27.346	8.6055	30710	.09637	1.119	.2967	.28954
190.00	3.6955	11.752	30.016	9.4395	33484	.10530	1.112	.2961	.30672
200.00	3.5767	11.374	32.761	10.302	36335	.11426	1.105	.2956	.32389
210.00	3.4688	11.031	35.592	11.193	39259	.12345	1.100	.2951	.34104
220.00	3.3704	10.718	38.509	12.110	42252	.13287	1.094	.2946	.35815
230.00	3.2803	10.431	41.508	13.053	45312	.14249	1.088	.2942	.37518
240.00	3.1975	10.168	44.588	14.021	48436	.15231	1.083	.2938	.39211
250.00	3.1212	9.9253	47.744	15.014	51621	.16233	1.078	.2934	.40888
260.00	3.0506	9.7009	50.976	16.030	54865	.17253	1.073	.2930	.42552
270.00	2.9851	9.4927	54.281	17.065	58164	.18291	1.068	.2927	.44204
280.00	2.9243	9.2993	57.656	18.131	61519	.19345	1.064	.2924	.45840
290.00	2.8676	9.1190	61.100	19.214	64923	.20416	1.059	.2920	.47458
300.00	2.8147	8.9506	64.610	20.318	68377	.21502	1.055	.2917	.49057
310.00	2.7651	8.7930	68.184	21.442	71880	.22604	1.051	.2914	.50634
320.00	2.7186	8.6453	71.822	22.585	75427	.23719	1.047	.2911	.52189
330.00	2.6750	8.5065	75.520	23.748	79019	.24849	1.043	.2909	.53720
340.00	2.6339	8.3759	79.276	24.930	82653	.25992	1.040	.2906	.55225
350.00	2.5952	8.2528	83.091	26.129	86328	.27147	1.036	.2903	.56703
360.00	2.5587	8.1367	86.960	27.346	90042	.28315	1.032	.2901	.58158
370.00	2.5242	8.0263	90.884	28.580	93793	.29495	1.029	.2898	.59591
380.00	2.4915	7.9229	94.861	29.830	97581	.30686	1.026	.2896	.61001
390.00	2.4605	7.8245	98.888	31.097	10140	.31888	1.022	.2893	.62386
400.00	2.4311	7.7310	102.97	32.379	10526	.33101	1.019	.2891	.63747
410.00	2.4032	7.6423	107.09	33.676	10915	.34323	1.016	.2888	.65076
420.00	2.3767	7.5579	111.26	34.989	11307	.35556	1.013	.2886	.66371
430.00	2.3514	7.4774	115.48	36.315	11702	.36798	1.010	.2884	.67631
440.00	2.3274	7.4011	119.74	37.656	12100	.38050	1.008	.2881	.68855
450.00	2.3044	7.3281	124.05	39.010	12501	.39310	1.005	.2879	.70045
460.00	2.2825	7.2584	128.40	40.377	12904	.40579	1.002	.2877	.71199
470.00	2.2616	7.1919	132.70	41.757	13314	.41856	.9995	.2875	.72319
480.00	2.2416	7.1282	137.22	43.150	13719	.43141	.9969	.2872	.73404
490.00	2.2224	7.0674	141.69	44.555	14130	.44434	.9944	.2870	.74455

# CALCIUM FLUORIDE

PROTON ENERGY MEV	ENERGY LOSS MEV/CM2	PROTON RANGE GH/CM2	PROTON PATH LENGTH GH/CM2	PATH LENGTH STRAGGLING GH/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.2041	146.19	146.61	1.4543	.2868	.75473
510.00	2.1866	150.73	151.17	1.4959	.2866	.76458
520.00	2.1697	155.31	155.76	1.5377	.2864	.77410
530.00	2.1536	159.93	160.38	1.5797	.2861	.78330
540.00	2.1380	164.57	165.04	1.6220	.2859	.79212
550.00	2.1231	169.25	169.74	1.6644	.2857	.80076
560.00	2.1080	173.97	174.46	1.7070	.2855	.80904
570.00	2.0950	178.71	179.22	1.7498	.2853	.81702
580.00	2.0818	183.49	184.01	1.7928	.2851	.82471
590.00	2.0690	188.29	188.83	1.8360	.2848	.83212
600.00	2.0567	193.13	193.68	1.8794	.2846	.83926
620.00	2.0335	202.88	203.46	1.9666	.2842	.85274
640.00	2.0119	212.74	213.35	2.0544	.2838	.86521
660.00	1.9917	222.70	223.34	2.1428	.2833	.87673
680.00	1.9729	232.77	233.43	2.2318	.2829	.88735
700.00	1.9553	242.92	243.61	2.3214	.2824	.89714
720.00	1.9389	253.17	253.89	2.4114	.2820	.90614
740.00	1.9235	263.50	264.24	2.5019	.2816	.91442
760.00	1.9090	273.91	274.68	2.5929	.2811	.92201
780.00	1.8954	284.39	285.19	2.6843	.2807	.92898
800.00	1.8827	294.95	295.78	2.7762	.2802	.93536
820.00	1.8707	305.58	306.44	2.8684	.2798	.94119
840.00	1.8594	316.28	317.16	2.9610	.2794	.94653
860.00	1.8487	327.04	327.95	3.0539	.2789	.95141
880.00	1.8387	337.86	338.81	3.1472	.2785	.95582
900.00	1.8292	348.74	349.72	3.2409	.2780	.95992
920.00	1.8202	359.68	360.68	3.3348	.2775	.96363
940.00	1.8117	370.68	371.71	3.4290	.2770	.96700
960.00	1.8037	381.74	382.80	3.5236	.2765	.97007
1000.00	1.7890	404.11	405.22	3.7135	.2750	.97543

THE ELECTRON DENSITY OF CALCIUM FLUORIDE IS 2.932E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.183 BEV, AND THE MINIMUM ENERGY LOSS IS 1.6605 MEV/GH/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 162.07 ELECTRON VOLTS

# CARBON DIOXIDE

ATOMS/  
MOLECULE  
2

ATOMIC  
NUMBER  
6

ELEMENT  
C

PERCENT  
BY WEIGHT  
27.2919  
72.7081

ADJUSTED  
IONIZATION  
POTENTIAL  
79.30  
9.50

ATOMIC  
WEIGHT  
12.011  
15.999

DENSITY = 1.9634 MG/CM3

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
		MG/CM2	METER	MG/CM2	METER	MG/CM2	PERCENT			
.10	668.66	16436	.00084	.16576	.00084	.00371	.00003	3.444	.8491	0.
.15	633.36	24107	.00123	.24259	.00124	.00742	.00004	3.060	.6238	0.
.20	568.70	32412	.00165	.32585	.00166	.00905	.00005	2.776	.5291	0.
.30	466.74	51809	.00264	.52032	.00265	.01283	.00007	2.466	.4395	0.
.40	393.47	75140	.00383	.75437	.00384	.01766	.00009	2.341	.3943	0.
.50	343.65	10232	.00521	1.0270	.00523	.02331	.00012	2.270	.3662	0.
.60	308.47	13299	.00677	1.3345	.00680	.02951	.00015	2.211	.3466	0.
.70	277.94	16759	.00851	1.6759	.00854	.03621	.00018	2.161	.3318	0.
.80	256.35	20440	.01041	2.0506	.01044	.04339	.00022	2.116	.3201	0.
.90	237.77	24477	.01247	2.4553	.01251	.05093	.00026	2.074	.3106	0.
1.00	219.17	28847	.01469	2.8931	.01474	.05901	.00030	2.040	.3025	0.
1.20	193.32	38558	.01964	3.8670	.01970	.07673	.00039	1.964	.2694	0.
1.40	173.62	49467	.02519	4.9606	.02527	.09602	.00049	1.936	.2495	0.
1.60	158.01	61534	.03134	6.1701	.03143	.11682	.00059	1.893	.2315	.00001
1.80	145.29	74718	.03806	7.4917	.03816	.13905	.00071	1.856	.2148	.00002
2.00	134.71	88993	.04533	8.9224	.04544	.16268	.00083	1.823	.2093	.00003
2.20	125.75	10433	.05314	10.460	.05327	.18766	.00096	1.794	.2044	.00004
2.40	118.03	12072	.06149	12.102	.06164	.21395	.00109	1.768	.2002	.00006
2.60	111.32	13814	.07036	13.848	.07053	.24152	.00123	1.744	.2064	.00008
2.80	105.41	15657	.07974	15.695	.07994	.27036	.00138	1.723	.2031	.00010
3.00	100.16	17600	.08967	17.642	.08985	.30043	.00153	1.703	.2000	.00012
3.20	95.472	19541	.10064	19.688	.10028	.33172	.00169	1.685	.2073	.00015
3.40	91.246	21780	.11093	21.832	.11119	.36421	.00185	1.666	.2048	.00018
3.60	87.417	24016	.12232	24.072	.12260	.39789	.00203	1.653	.2025	.00021
3.80	83.929	26347	.13419	26.407	.13450	.43274	.00220	1.639	.2003	.00024
4.00	80.737	28771	.14654	28.837	.14687	.46875	.00239	1.625	.2028	.00028
4.20	77.759	31292	.15937	31.363	.15974	.50594	.00258	1.613	.2065	.00032
4.40	75.059	33905	.17268	33.982	.17307	.54428	.00277	1.602	.2048	.00036
4.60	72.558	36609	.18646	36.691	.18687	.58373	.00297	1.591	.2031	.00040
4.80	70.236	39406	.20070	39.494	.20115	.62428	.00316	1.581	.2016	.00045

## CARBON DIOXIDE

PRCTCN ENERGY MEV	ENERGY LOSS MEV/ GM/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH		GM/CH2	PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
			GH/CH2	METER		METER	PERCENT		
5.00	68.072	133.65	.04239	.21588	.0067	.00339	1.571	.2202	.00049
5.50	63.234	124.19	.05001	.25472	.0077	.00395	1.549	.2170	.00062
6.00	59.132	116.10	.05807	.29639	.0089	.00453	1.530	.2141	.00130
6.50	55.561	109.09	.06678	.34084	.0101	.00516	1.513	.2116	.00225
7.00	52.435	102.95	.07619	.38804	.0114	.00581	1.498	.2093	.00411
7.50	49.633	97.450	.08680	.43799	.0128	.00650	1.484	.2073	.00664
8.00	47.181	92.636	.09613	.49063	.0142	.00722	1.472	.2055	.00916
8.50	44.982	88.318	.10696	.54589	.0157	.00797	1.460	.2038	.01168
9.00	42.927	84.420	.11832	.60261	.0172	.00875	1.450	.2022	.01420
9.50	41.195	80.883	.13018	.66304	.0188	.00957	1.440	.2008	.01671
10.00	39.553	77.658	.14255	.72749	.0204	.01041	1.431	.1995	.01923
11.00	36.664	71.987	.16878	.86133	.0239	.01218	1.415	.1971	.02425
12.00	34.204	67.137	.19699	1.0053	.0276	.01408	1.400	.1950	.02926
13.00	32.082	62.991	.22714	1.1591	.0316	.01608	1.387	.1932	.03432
14.00	30.232	59.358	.25921	1.3202	.0357	.01820	1.376	.1916	.03935
15.00	28.602	56.158	.29316	1.4931	.0401	.02042	1.365	.1901	.04440
16.00	27.156	53.319	.32899	1.6788	.0447	.02276	1.356	.1887	.04944
17.00	25.863	50.779	.36667	1.8675	.0495	.02520	1.347	.1875	.05450
18.00	24.699	48.495	.40619	2.0688	.0545	.02775	1.339	.1864	.05956
19.00	23.646	46.427	.44750	2.2792	.0597	.03049	1.331	.1854	.06463
20.00	22.638	44.546	.49061	2.4988	.0651	.03312	1.324	.1844	.06970
22.00	21.009	41.250	.58213	2.9703	.0765	.03895	1.311	.1827	.07986
24.00	19.386	38.455	.68063	3.4666	.0886	.04515	1.300	.1812	.09005
26.00	18.362	36.052	.78598	4.0031	.01016	.05172	1.290	.1799	.09621
28.00	17.298	33.822	.89807	4.5740	.01152	.05867	1.280	.1787	.09823
30.00	16.363	32.128	1.0168	5.1787	.01296	.06599	1.272	.1776	.10035
32.00	15.536	30.504	1.1421	5.8271	.01446	.07367	1.264	.1767	.10251
34.00	14.798	29.055	1.2738	6.4876	.01604	.08169	1.257	.1758	.10475
36.00	14.135	27.754	1.4119	7.1910	.01758	.09006	1.250	.1750	.10705
38.00	13.537	26.578	1.5563	7.9264	.01939	.09877	1.244	.1743	.10940
40.00	12.993	25.511	1.7069	8.6933	.02117	.10781	1.238	.1736	.11181
45.00	11.030	23.228	2.1100	10.747	.02588	.13183	1.235	.1721	.11717
50.00	10.883	21.368	2.5504	12.990	.03099	.15782	1.213	.1708	.12536
55.00	10.096	19.323	3.0270	15.417	.03646	.18568	1.202	.1697	.13096
60.00	9.4310	18.117	3.5390	18.025	.04238	.21536	1.193	.1688	.13786
65.00	8.8614	17.399	4.0854	20.842	.04846	.24600	1.184	.1679	.14501
70.00	8.3677	16.429	4.6654	23.762	.05496	.27993	1.176	.1672	.15237
75.00	7.9356	15.581	5.2783	26.883	.06179	.31471	1.169	.1665	.15992
80.00	7.5541	14.832	5.9233	30.168	.06893	.35107	1.165	.1659	.16763
90.00	6.9106	13.568	7.3069	37.215	.08411	.42837	1.149	.1648	.18337

## CARBON DIOXIDE

PROTON ENERGY MEV	ENERGY LOSS KEV/CH	PROTON RANGE		PROTON PATH LENGTH GM/CH <sup>2</sup> METER		GM/CH <sup>2</sup>	PATH LENGTH STRAGGLING METER PERCENT		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CH <sup>2</sup>	METER	GM/CH <sup>2</sup>	METER		GM/CH <sup>2</sup>	PERCENT		
100.00	6.3885	12.543	44.876	8.8253	44.950	1.0043	51148	1.138	.1639	.19938
110.00	5.9561	11.694	53.127	10.440	53.214	1.1782	60008	1.128	.1631	.21570
120.00	5.5920	10.979	61.944	12.182	62.045	1.3623	69326	1.118	.1624	.23244
130.00	5.2611	10.369	71.307	14.023	71.423	1.5561	79256	1.110	.1618	.24946
140.00	5.0125	9.8416	81.195	15.968	81.327	1.7591	89593	1.102	.1613	.26667
150.00	4.7780	9.3813	91.591	18.012	91.738	1.9702	1.0037	1.094	.1608	.28396
160.00	4.5716	8.9760	102.48	20.152	102.64	2.1907	1.1158	1.087	.1603	.30133
170.00	4.3895	8.6164	113.83	22.386	114.01	2.4186	1.2318	1.080	.1599	.31879
180.00	4.2240	8.2953	125.65	24.709	125.85	2.6540	1.3517	1.074	.1596	.33628
190.00	4.0779	8.0067	137.90	27.119	138.12	2.8965	1.4753	1.068	.1592	.35372
200.00	3.9452	7.7460	150.58	29.612	150.82	3.1460	1.6023	1.062	.1589	.37108
210.00	3.8246	7.5094	163.67	32.187	163.93	3.4020	1.7327	1.057	.1586	.38832
220.00	3.7148	7.2936	177.17	34.841	177.45	3.6642	1.8662	1.052	.1583	.40546
230.00	3.6142	7.0961	191.05	37.570	191.35	3.9325	2.0029	1.047	.1580	.42244
240.00	3.5218	6.9147	205.32	40.374	205.63	4.2065	2.1424	1.042	.1578	.43923
250.00	3.4366	6.7476	219.92	43.249	220.27	4.4860	2.2848	1.037	.1575	.45581
260.00	3.3579	6.5930	234.90	46.193	235.27	4.7708	2.4298	1.033	.1573	.47218
270.00	3.2849	6.4497	250.21	49.204	250.60	5.0606	2.5775	1.029	.1571	.48836
280.00	3.2171	6.3165	265.85	52.280	266.27	5.3553	2.7276	1.024	.1568	.50433
290.00	3.1539	6.1925	281.82	55.420	282.26	5.6547	2.8800	1.020	.1566	.52007
300.00	3.0949	6.0766	298.10	58.621	298.57	5.9596	3.0348	1.016	.1564	.53556
310.00	3.0397	5.9682	314.68	61.882	315.17	6.2667	3.1917	1.013	.1562	.55081
320.00	2.9879	5.8666	331.56	65.200	332.07	6.5790	3.3508	1.009	.1560	.56594
330.00	2.9393	5.7711	348.72	68.468	349.26	6.8953	3.5119	1.006	.1558	.58063
340.00	2.8936	5.6813	366.16	71.892	366.73	7.2154	3.6749	1.002	.1556	.59516
350.00	2.8505	5.5963	383.87	75.486	384.46	7.5392	3.8399	.9988	.1555	.60943
360.00	2.8098	5.5167	401.64	79.020	402.46	7.8666	4.0066	.9955	.1553	.62347
370.00	2.7713	5.4412	420.06	82.604	420.71	8.1974	4.1751	.9924	.1551	.63733
380.00	2.7349	5.3698	438.53	86.102	439.21	8.5315	4.3452	.9893	.1549	.65099
390.00	2.7004	5.3021	457.25	89.916	457.96	8.8687	4.5170	.9863	.1548	.66444
400.00	2.6677	5.2378	476.20	93.642	476.93	9.2091	4.6903	.9834	.1546	.67765
410.00	2.6366	5.1768	495.37	97.413	495.14	9.5524	4.8652	.9806	.1544	.69054
420.00	2.6071	5.1188	514.77	101.23	515.57	9.8986	5.0415	.9779	.1543	.70305
430.00	2.5789	5.0635	534.38	105.08	535.21	1.0247	5.2192	.9752	.1541	.71517
440.00	2.5521	5.0109	554.21	108.98	555.06	1.0599	5.3983	.9726	.1540	.72691
450.00	2.5266	4.9607	574.24	112.75	575.12	1.0953	5.5787	.9700	.1538	.73827
460.00	2.5022	4.9128	594.46	116.72	595.38	1.1310	5.7603	.9675	.1536	.74925
470.00	2.4789	4.8671	614.88	120.91	615.83	1.1669	5.9432	.9651	.1535	.75986
480.00	2.4566	4.8233	635.49	124.96	636.47	1.2030	6.1273	.9627	.1533	.77010
490.00	2.4353	4.7814	656.28	129.05	657.29	1.2394	6.3125	.9604	.1532	.77998

## CARBON DIOXIDE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON RANGE METER	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH METER	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING METER	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.4148	132.97	677.26	133.18	678.29	1.2760	6.4989	.1530	.78951
510.00	2.3953	137.13	698.40	137.34	699.47	1.3128	6.6863	.1529	.79869
520.00	2.3765	141.31	719.72	141.53	720.82	1.3498	6.8748	.1527	.80754
530.00	2.3585	145.53	741.20	145.75	742.33	1.3870	7.0643	.1526	.81605
540.00	2.3412	149.70	762.84	150.01	764.01	1.4244	7.2547	.1524	.82423
550.00	2.3246	154.06	784.64	154.29	785.84	1.4620	7.4461	.1523	.83210
560.00	2.3086	158.37	806.60	158.61	807.83	1.4997	7.6385	.1521	.83966
570.00	2.2933	162.71	828.70	162.96	829.96	1.5377	7.8317	.1520	.84693
580.00	2.2785	167.08	850.95	167.33	852.24	1.5758	8.0258	.1518	.85390
590.00	2.2643	171.47	873.34	171.73	874.67	1.6141	8.2208	.1517	.86059
600.00	2.2506	175.90	895.87	176.16	897.23	1.6525	8.4165	.1515	.86701
620.00	2.2246	184.82	941.33	185.10	942.76	1.7299	8.8104	.1512	.87905
640.00	2.2005	193.85	987.31	194.14	988.80	1.8078	9.2073	.1510	.89010
660.00	2.1780	202.97	1033.8	203.28	1035.3	1.8863	9.6071	.1507	.90023
680.00	2.1569	212.19	1080.7	212.51	1082.3	1.9653	10.010	.1504	.90949
700.00	2.1373	221.49	1128.1	221.82	1129.8	2.0448	10.415	.1501	.91796
720.00	2.1189	230.87	1175.9	231.22	1177.6	2.1248	10.822	.1498	.92568
740.00	2.1017	240.34	1224.1	240.70	1225.9	2.2053	11.232	.1495	.93272
760.00	2.0855	249.80	1272.7	250.25	1274.6	2.2862	11.644	.1492	.93913
780.00	2.0703	259.49	1321.6	259.88	1323.6	2.3674	12.058	.1489	.94496
800.00	2.0560	269.17	1370.9	269.57	1373.0	2.4491	12.474	.1486	.95026
820.00	2.0425	278.92	1420.6	279.33	1422.7	2.5312	12.892	.1484	.95507
840.00	2.0298	288.73	1470.5	289.16	1472.7	2.6136	13.312	.1481	.95943
860.00	2.0179	298.60	1520.8	299.04	1523.1	2.6964	13.733	.1478	.96339
880.00	2.0066	308.53	1571.4	308.98	1573.7	2.7795	14.156	.1475	.96697
900.00	1.9959	318.51	1622.2	318.98	1624.6	2.8629	14.581	.1472	.97021
920.00	1.9858	328.55	1673.4	329.04	1675.8	2.9466	15.007	.1469	.97315
940.00	1.9763	338.65	1724.8	339.14	1727.3	3.0306	15.422	.1466	.97580
960.00	1.9673	348.79	1776.5	349.31	1779.1	3.1148	15.864	.1462	.97820
1000.00	1.9506	369.32	1881.0	369.85	1883.7	3.2842	16.727	.1454	.98234

THE ELECTRON DENSITY OF CARBON DIOXIDE IS 3.012E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.267 BEV, AND THE MINIMUM ENERGY LOSS IS 1.8072 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 92.20 ELECTRON VOLTS



# EMULSION (ILFORD G-5 AT 58 PERCENT HUMIDITY)

PROTON ENERGY MEV	ENERGY LOSS HEV/CM	PROTON RANGE MG/CM <sup>2</sup>	PROTON PATH LENGTH MM	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
1.00	381.64	1460.8	0.0100	39986	0.0102	0.142	0.0008	1.789	0.
1.20	338.87	1297.1	0.0136	52681	0.0138	0.3524	0.0009	1.429	0.
1.40	301.62	1154.5	0.0177	68512	0.0179	0.3993	0.0010	1.296	0.
1.60	247.88	948.84	0.0272	1.0522	0.0275	0.5176	0.0014	1.209	0.
1.80	212.50	813.40	0.0384	1.4892	0.0389	0.6702	0.0018	1.185	0.
2.00	187.98	719.55	0.0514	1.9904	0.0520	0.8447	0.0022	1.173	0.
2.20	169.95	650.55	0.0659	2.5506	0.0666	1.0338	0.0027	1.165	0.
2.40	155.44	594.99	0.0818	3.1459	0.0827	1.2358	0.0032	1.157	0.
2.60	143.89	550.77	0.0990	3.8351	0.1002	1.4498	0.0038	1.149	0.
2.80	135.12	517.23	0.1176	4.5518	0.1189	1.6709	0.0044	1.140	0.
3.00	126.35	483.65	0.1373	5.3173	0.1389	1.9989	0.0050	1.130	0.
3.20	113.47	434.33	0.1806	6.9901	0.1826	2.3776	0.0062	1.112	0.
3.40	103.41	395.63	0.2284	8.8393	0.2309	2.8808	0.0075	1.094	0.
3.60	95.385	365.11	0.2806	10.857	0.2836	3.4954	0.0089	1.078	0.
3.80	88.680	339.45	0.3369	13.033	0.3405	3.9539	0.0103	1.062	0.
4.00	83.003	317.72	0.3972	15.366	0.4014	4.5332	0.0118	1.048	0.0001
4.20	78.126	299.05	0.4615	17.850	0.4663	5.3399	0.0134	1.035	0.0001
4.40	73.881	282.80	0.5297	20.434	0.5351	5.7714	0.0151	1.022	0.0002
4.60	70.148	268.51	0.6016	23.264	0.6078	6.4260	0.0168	1.011	0.0002
4.80	66.833	255.82	0.6772	26.185	0.6841	7.1022	0.0186	1.000	0.0003
5.00	63.864	244.46	0.7565	29.248	0.7641	7.7993	0.0204	0.9904	0.0003
5.20	61.185	234.20	0.8394	32.448	0.8477	8.5164	0.0222	0.9810	0.0004
5.40	58.754	224.90	0.9258	35.785	0.9349	9.2531	0.0242	0.9722	0.0005
5.60	56.542	216.43	1.0157	39.256	1.0256	1.0009	0.0261	0.9641	0.0006
5.80	54.510	208.65	1.1090	42.859	1.1197	1.0783	0.0282	0.9563	0.0007
6.00	52.653	201.54	1.2057	46.592	1.2172	1.1576	0.0302	0.9490	0.0008
6.20	50.924	194.93	1.3057	50.456	1.3182	1.2385	0.0324	0.9421	0.0009
6.40	49.334	188.84	1.4091	54.447	1.4224	1.3212	0.0345	0.9354	0.0011
6.60	47.853	183.17	1.5159	58.563	1.5299	1.4056	0.0367	0.9292	0.0011
6.80	46.472	177.89	1.6256	62.806	1.6408	1.4917	0.0390	0.9232	0.0012

DENSITY = 3.8278 GM/CM<sup>3</sup>

# EMULSION (G-5)

PROTON ENERGY MEV	ENERGY LOSS MEV/CH GM/CH2	PROTON RANGE GM/CH2	PROTON PATH LENGTH CM GM/CH2	PATH LENGTH STRAGGLING CM GM/CH2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	45.181	172.94	0.6656	0.1739	0.0158	0.0014
5.50	42.277	161.83	0.7862	0.2054	0.0181	0.0017
6.00	39.775	152.25	0.9001	0.2373	0.0204	0.0042
6.50	37.590	143.89	1.0284	0.2711	0.0229	0.0082
7.00	35.672	136.54	1.1639	0.3041	0.0255	0.0137
7.50	33.959	129.99	1.3179	0.3443	0.0281	0.0200
8.00	32.426	124.12	1.4866	0.3837	0.0309	0.0263
8.50	31.041	118.02	1.6262	0.4248	0.0337	0.0327
9.00	29.783	114.00	1.7757	0.4676	0.0367	0.0391
9.50	28.636	109.61	1.9456	0.5083	0.0397	0.0455
10.00	27.583	105.58	2.1222	0.5544	0.0428	0.0519
11.00	25.728	98.481	2.5156	0.6572	0.0493	0.0649
12.00	24.133	92.375	2.8936	0.7521	0.0561	0.0781
13.00	22.747	87.071	3.3442	0.8737	0.0633	0.0914
14.00	21.528	82.403	3.7662	0.9939	0.0708	0.1049
15.00	20.447	78.268	4.2731	1.1163	0.0787	0.1186
16.00	19.493	74.617	4.7741	1.2472	0.0868	0.1352
17.00	18.623	71.286	5.2991	1.3844	0.0953	0.1542
18.00	17.840	68.287	5.8481	1.5278	0.1041	0.1746
19.00	17.127	65.560	6.4201	1.6772	0.1132	0.1969
20.00	16.476	63.069	7.0156	1.8328	0.1226	0.2203
22.00	15.329	56.676	8.2129	2.1618	0.1423	0.2752
24.00	14.348	54.923	9.5529	2.5143	0.1631	0.3307
26.00	13.501	51.679	1.1064	2.8994	0.1850	0.3666
28.00	12.760	48.841	1.2496	3.2646	0.2080	0.3819
30.00	12.105	46.336	1.4095	3.6823	0.2320	0.3979
32.00	11.522	44.103	1.5777	4.1516	0.2570	0.4145
34.00	11.003	42.158	1.7542	4.6160	0.2831	0.4316
36.00	10.535	40.325	1.9388	5.0650	0.3101	0.4493
38.00	10.110	38.701	2.1314	5.5681	0.3381	0.4674
40.00	9.7240	37.221	2.3317	6.0916	0.3670	0.4861
45.00	8.8940	34.045	2.8665	7.4835	0.4431	0.5344
50.00	8.2122	31.435	3.4482	9.0064	0.5248	0.5850
55.00	7.6420	29.254	4.0756	1.0647	0.6116	0.6380
60.00	7.1592	27.404	4.7476	1.2403	0.7035	0.6935
65.00	6.7435	25.813	5.4629	1.4272	0.8003	0.7513
70.00	6.3818	24.428	6.2205	1.6251	0.9018	0.8112
75.00	6.0654	23.213	7.0192	1.8338	1.0078	0.8730
80.00	5.7834	22.138	7.8564	2.0530	1.1182	0.9354
90.00	5.3077	20.317	9.6538	2.5220	1.3515	1.0672

# EMULSION (G-5)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH GM/CM2 CH		PATH LENGTH STRAGGLING GM/CM2 CH PERCENT		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CH	GM/CM2	CH	GM/CM2	CH PERCENT		
100.00	4.9201	11.600	3.0305	11.678	3.0507	.16007	.04182	1.371	.6638
110.00	4.5980	13.691	3.5766	13.782	3.6004	.18649	.04872	1.353	.6606
120.00	4.3270	15.920	4.1589	16.025	4.1865	.21430	.05598	1.337	.6580
130.00	4.0925	18.281	4.7760	18.482	4.8075	.24344	.06360	1.323	.6557
140.00	3.8908	20.773	5.4269	20.910	5.4626	.27388	.07155	1.310	.6537
150.00	3.7144	23.388	6.1099	23.541	6.1500	.30552	.07982	1.298	.6520
160.00	3.5588	26.121	6.8240	26.292	6.8687	.33829	.08838	1.287	.6505
170.00	3.4205	28.971	7.5685	29.160	7.6180	.37214	.09722	1.276	.6491
180.00	3.2968	31.930	8.3416	32.138	8.3960	.40702	.10633	1.266	.6479
190.00	3.1855	34.997	9.1428	35.225	9.2023	.44288	.11570	1.257	.6469
200.00	3.0863	38.167	9.9711	38.415	10.036	.47966	.12531	1.249	.6459
210.00	2.9947	41.435	10.825	41.705	10.895	.51728	.13514	1.240	.6449
220.00	2.9111	44.803	11.705	45.094	11.781	.55576	.14519	1.232	.6442
230.00	2.8346	48.259	12.608	48.572	12.689	.59506	.15546	1.225	.6435
240.00	2.7642	51.812	13.536	52.147	13.623	.63513	.16593	1.218	.6428
250.00	2.6993	55.451	14.486	55.809	14.580	.67595	.17659	1.211	.6422
260.00	2.6392	59.175	15.459	59.557	15.559	.71747	.18744	1.205	.6416
270.00	2.5835	62.982	16.454	63.388	16.560	.75968	.19846	1.198	.6411
280.00	2.5317	66.867	17.469	67.298	17.581	.80254	.20966	1.193	.6406
290.00	2.4834	70.831	18.504	71.288	18.624	.84603	.22102	1.187	.6401
300.00	2.4383	74.872	19.560	75.354	19.686	.89011	.23254	1.181	.6396
310.00	2.3961	78.984	20.634	79.492	20.767	.93477	.24420	1.175	.6392
320.00	2.3565	83.167	21.727	83.702	21.867	.97997	.25602	1.171	.6388
330.00	2.3193	87.419	22.838	87.980	22.985	1.0257	.26796	1.166	.6384
340.00	2.2843	91.737	23.966	92.326	24.120	1.0720	.28004	1.161	.6380
350.00	2.2513	96.120	25.111	96.737	25.272	1.1187	.29225	1.156	.6373
360.00	2.2201	100.57	26.273	101.21	26.441	1.1659	.30458	1.152	.6370
370.00	2.1907	105.07	27.449	105.74	27.625	1.2135	.31703	1.148	.6367
380.00	2.1628	109.63	28.642	110.34	28.825	1.2616	.32959	1.143	.6363
390.00	2.1364	114.26	29.849	114.99	30.040	1.3101	.34226	1.139	.6360
400.00	2.1113	118.94	31.072	119.70	31.271	1.3590	.35504	1.135	.6357
410.00	2.0875	123.67	32.305	124.46	32.515	1.4083	.36791	1.132	.6353
420.00	2.0648	128.46	33.560	129.28	33.774	1.4579	.38088	1.128	.6350
430.00	2.0433	133.30	34.824	134.15	35.046	1.5080	.39395	1.124	.6347
440.00	2.0227	138.19	36.101	139.07	36.331	1.5583	.40710	1.121	.6344
450.00	2.0032	143.12	37.391	144.05	37.629	1.6090	.42035	1.117	.6341
460.00	1.9845	148.11	38.693	149.05	38.940	1.6600	.43367	1.114	.6338
470.00	1.9566	153.14	40.007	154.12	40.262	1.7113	.44708	1.110	.6335
480.00	1.9495	158.22	41.333	159.22	41.597	1.7629	.46056	1.107	.6332
490.00	1.9332	163.33	42.671	164.38	42.942	1.8149	.47413	1.104	.6329

# EMULSION (G-5)

PROTON ENERGY MEV	ENERGY LOSS MEV/CH	PROTON RANGE GM/CM2	CH	PROTON PATH LENGTH GM/CM2	CH	PATH LENGTH STRAGGLING GM/CM2	CH	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.9175	7.3400	168.50	44.019	169.57	44.299	1.8670	1.101	.6326	.70080
510.00	1.9026	7.2826	173.70	45.379	174.81	45.667	1.9195	1.098	.6323	.71142
520.00	1.8882	7.2276	178.94	46.748	180.08	47.046	1.9722	1.095	.6320	.72177
530.00	1.8744	7.1748	184.23	48.129	185.40	48.433	2.0252	1.092	.6317	.73183
540.00	1.8612	7.1242	189.55	49.519	190.75	49.833	2.0784	1.090	.6314	.74160
550.00	1.8485	7.0755	194.91	50.919	196.14	51.242	2.1318	1.087	.6311	.75110
560.00	1.8362	7.0287	200.30	52.328	201.57	52.660	2.1855	1.084	.6308	.76032
570.00	1.8245	6.9838	205.73	53.746	207.04	54.088	2.2394	1.082	.6306	.76928
580.00	1.8132	6.9405	211.20	55.174	212.53	55.524	2.2935	1.079	.6303	.77796
590.00	1.8023	6.8988	216.69	56.610	218.07	56.969	2.3478	1.077	.6300	.78638
600.00	1.7918	6.8587	222.22	58.055	223.63	58.423	2.4023	1.074	.6297	.79454
620.00	1.7720	6.7828	233.38	60.970	234.86	61.356	2.5119	1.070	.6290	.81010
640.00	1.7536	6.7123	244.66	63.916	246.20	64.320	2.6222	1.065	.6284	.82467
660.00	1.7364	6.6465	256.05	66.892	257.67	67.314	2.7332	1.061	.6278	.83830
680.00	1.7204	6.5852	267.55	69.897	269.24	70.338	2.8448	1.057	.6272	.85103
700.00	1.7054	6.5279	279.14	72.929	280.92	73.388	2.9570	1.053	.6266	.86289
720.00	1.6914	6.4743	290.86	75.986	292.69	76.465	3.0698	1.049	.6259	.87393
740.00	1.6783	6.4240	302.67	79.073	304.58	79.570	3.1832	1.045	.6253	.88419
760.00	1.6659	6.3769	314.57	82.179	316.54	82.694	3.2971	1.042	.6246	.89372
780.00	1.6544	6.3327	326.54	85.308	328.59	85.843	3.4114	1.038	.6239	.90254
800.00	1.6435	6.2911	338.60	88.457	340.72	89.012	3.5262	1.035	.6237	.91069
820.00	1.6333	6.2520	350.73	91.628	352.93	92.202	3.6414	1.032	.6231	.91823
840.00	1.6237	6.2152	362.94	94.819	365.22	95.411	3.7571	1.029	.6224	.92519
860.00	1.6146	6.1805	375.22	98.025	377.57	98.639	3.8732	1.026	.6217	.93160
880.00	1.6061	6.1478	387.57	101.25	390.00	101.99	3.9896	1.023	.6210	.93751
900.00	1.5980	6.1169	399.98	104.49	402.48	105.15	4.1064	1.020	.6203	.94295
920.00	1.5904	6.0878	412.46	107.75	415.03	108.43	4.2235	1.018	.6195	.94795
940.00	1.5832	6.0602	425.04	111.04	427.69	111.73	4.3410	1.015	.6187	.95253
960.00	1.5764	6.0342	437.66	114.34	440.38	115.05	4.4587	1.012	.6173	.95674
1000.00	1.5639	5.9863	463.15	121.00	466.02	121.75	4.6951	1.008	.6155	.96412

THE ELECTRON DENSITY OF EMULSION (G-5) IS 2.730E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.092 BEV, AND THE MINIMUM ENERGY LOSS IS 1.4622 MEV/GR/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 286.60 ELECTRON VOLTS

# EMULSION (KODAK NTA AT 50 PERCENT HUMIDITY)

PROTON ENERGY MEV	ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL	PATH LENGTH STRAGGLING MM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	AG	47	1.0000	42.3000	107.87	465.0	.02997	1.538	0.
.15	BR	35	.97013	30.4000	79.909	348.5	.03360	1.215	0.
.20	I	53	.02813	1.4000	126.90	525.5	.03807	1.100	0.
.30	C	6	1.9533	9.2000	12.011	77.30	.04930	1.027	0.
.40	H	1	4.0479	1.6000	1.0380	18.30	.06381	1.006	0.
.50	O	8	1.9605	12.3000	15.999	98.50	.08744	.9966	0.
.60	N	7	.50978	2.8000	14.007	99.50	.09843	.9894	0.
.70							.11780	.9830	0.
.80							.13827	.9762	0.
.90							.15944	.9691	0.
1.00							.18131	.9614	0.
1.20							.22725	.9461	0.
1.40							.27553	.9320	0.
1.60							.32587	.9188	0.
1.80							.37850	.9064	.00001
2.00							.43407	.8952	.00001
2.20							.49227	.8846	.00001
2.40							.55285	.8750	.00002
2.60							.61567	.8659	.00003
2.80							.68060	.8575	.00004
3.00							.74754	.8497	.00005
3.20							.81643	.8423	.00006
3.40							.88722	.8354	.00007
3.60							.95986	.8290	.00008
3.80							1.0343	.8229	.00009
4.00							1.1105	.8171	.00011
4.20							1.1883	.8117	.00012
4.40							1.2679	.8065	.00014
4.60							1.3491	.8015	.00015
4.80							1.4319	.7969	.00017

DENSITY = 3.0570 GM/CM3

# EMULSION (NTA)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2 CM	PROTON PATH LENGTH GM/CM2 CM	PATH LENGTH STRAGGLING GM/CM2 CM PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	47.916	0.6224	0.6274	0.0152	0.7924	.00019
5.50	44.785	0.7296	0.7354	0.0173	0.7822	.00024
6.00	42.089	0.8440	0.8505	0.0196	0.7730	.00055
6.50	39.739	0.9655	0.9729	0.0220	0.7647	.00104
7.00	37.677	1.0939	1.1022	0.0245	0.7571	.00176
7.50	35.836	1.2290	1.2383	0.0270	0.7502	.00269
8.00	34.194	1.3709	1.3812	0.0297	0.7438	.00359
8.50	32.712	1.5194	1.5307	0.0324	0.7379	.00449
9.00	31.367	1.6745	1.6869	0.0353	0.7325	.00539
9.50	30.143	1.8361	1.8495	0.0382	0.7275	.00629
10.00	29.019	2.0041	2.0186	0.0412	0.7228	.00719
11.00	27.042	2.3589	2.3758	0.0475	0.7142	.00901
12.00	25.344	2.7386	2.7581	0.0540	0.7067	.01084
13.00	23.871	3.1427	3.1648	0.0610	0.6999	.01268
14.00	22.577	3.5709	3.5958	0.0682	0.6938	.01454
15.00	21.430	4.0227	4.0506	0.0758	0.6883	.01642
16.00	20.418	4.4979	4.5288	0.0837	0.6833	.01854
17.00	19.497	4.9960	5.0302	0.0919	0.6788	.02085
18.00	18.668	5.5172	5.5546	0.1004	0.6747	.02329
19.00	17.915	6.0605	6.1014	0.1092	0.6708	.02588
20.00	17.228	6.6243	6.6708	0.1182	0.6671	.02857
22.00	16.017	7.8237	7.8757	0.1372	0.6607	.03466
24.00	14.983	9.1076	9.1677	0.1574	0.6551	.04081
26.00	14.090	1.0478	1.0346	0.1785	0.6499	.0472
28.00	13.310	1.1930	1.2007	0.2008	0.6455	.05331
30.00	12.622	1.3464	1.3551	0.2240	0.6414	.0596
32.00	12.010	1.5079	1.5175	0.2483	0.6378	.0668
34.00	11.465	1.6774	1.6881	0.2735	0.6346	.0745
36.00	10.973	1.8547	1.8665	0.2996	0.6316	.0827
38.00	10.528	2.0397	2.0526	0.3267	0.6289	.0914
40.00	10.122	2.2323	2.2464	0.3547	0.6263	.1006
45.00	9.2520	2.7466	2.7637	0.4285	0.6208	.1204
50.00	8.5382	3.3064	3.3269	0.5076	0.6151	.1423
55.00	7.9423	3.9104	3.9344	0.5919	0.6121	.1666
60.00	7.4370	4.5576	4.5855	0.6810	0.6087	.1934
65.00	7.0026	5.2468	5.2788	0.7748	0.6058	.2226
70.00	6.6250	5.9770	6.0137	0.8733	0.6032	.2539
75.00	6.2937	6.7471	6.7870	0.9761	0.6008	.2869
80.00	6.0005	7.5263	7.6018	1.0832	0.5988	.3215
90.00	5.5044	9.2884	9.3440	1.3097	0.5953	.4648

# EMULSION (NTA)

PROTON ENERGY HEV	ENERGY LOSS HEV/ GM/CH2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CH2	CM	GM/CH2	CM	GM/CH2	PERCENT		
100.00	5.1004	11.167	3.6528	11.233	3.6746	.1551	1.381	.5924	.13021
110.00	4.7649	13.185	4.3130	13.263	4.3386	.1803	1.343	.5899	.14434
120.00	4.4826	15.338	5.0173	15.428	5.0469	.2078	1.347	.5879	.15893
130.00	4.2388	17.619	5.7637	17.723	5.7976	.23615	1.302	.5861	.17389
140.00	4.0289	20.027	6.5511	20.145	6.5897	.26573	1.319	.5845	.18913
150.00	3.8455	22.554	7.3778	22.686	7.4210	.29647	1.307	.5832	.20457
160.00	3.6835	25.196	8.2421	25.343	8.2903	.32832	1.295	.5820	.22022
170.00	3.5399	27.951	9.1434	28.115	9.1968	.36123	1.285	.5809	.23609
180.00	3.4113	30.813	10.079	30.993	10.138	.39514	1.275	.5800	.25213
190.00	3.2956	33.779	11.050	33.976	11.114	.43000	1.266	.5792	.26828
200.00	3.1923	36.046	12.053	37.060	12.123	.46577	1.257	.5785	.28449
210.00	3.0972	40.008	13.087	40.241	13.164	.50236	1.248	.5778	.30071
220.00	3.0104	43.266	14.153	43.518	14.235	.53978	1.240	.5771	.31693
230.00	2.9309	46.611	15.247	46.881	15.336	.57800	1.233	.5767	.33309
240.00	2.8578	50.049	16.372	50.339	16.467	.61698	1.226	.5761	.34916
250.00	2.7904	53.571	17.524	53.881	17.626	.65662	1.219	.5757	.36512
260.00	2.7282	57.176	18.703	57.507	18.812	.69709	1.212	.5752	.38100
270.00	2.6700	60.861	19.909	61.213	20.024	.73816	1.206	.5748	.39682
280.00	2.6165	64.623	21.139	64.997	21.262	.77986	1.200	.5744	.41255
290.00	2.5663	68.462	22.395	68.857	22.524	.82217	1.194	.5741	.42818
300.00	2.5195	72.374	23.675	72.722	23.812	.86507	1.188	.5737	.44366
310.00	2.4757	76.356	24.977	76.797	25.122	.90853	1.183	.5734	.45907
320.00	2.4346	80.407	26.303	80.871	26.454	.95252	1.178	.5731	.47430
330.00	2.3960	84.525	27.650	85.012	27.809	.99703	1.173	.5728	.48937
340.00	2.3597	88.700	29.018	89.219	29.185	1.0420	1.168	.5725	.50425
350.00	2.3254	92.954	30.407	93.469	30.582	1.0875	1.163	.5719	.51894
360.00	2.2931	97.261	31.816	97.820	31.999	1.1335	1.159	.5716	.53344
370.00	2.2625	101.62	33.243	102.21	33.434	1.1798	1.154	.5714	.54775
380.00	2.2336	106.05	34.690	106.66	34.889	1.2267	1.150	.5711	.56187
390.00	2.2062	110.53	36.155	111.16	36.363	1.2739	1.144	.5709	.57578
400.00	2.1802	115.06	37.639	115.72	37.855	1.3215	1.142	.5706	.58947
410.00	2.1555	119.65	39.139	120.34	39.364	1.3694	1.138	.5703	.60391
420.00	2.1320	124.29	40.657	125.00	40.880	1.4178	1.134	.5701	.61806
430.00	2.1096	128.98	42.191	129.72	42.433	1.4665	1.131	.5699	.63283
440.00	2.0883	133.72	43.741	134.48	43.992	1.5155	1.127	.5696	.64750
450.00	2.0680	138.50	45.307	139.30	45.566	1.5649	1.123	.5694	.66150
460.00	2.0486	143.33	46.887	144.15	47.155	1.6146	1.120	.5691	.67575
470.00	2.0300	148.21	48.482	149.06	48.760	1.6645	1.117	.5689	.68943
480.00	2.0123	153.13	50.092	154.01	50.378	1.7148	1.113	.5686	.70380
490.00	1.9955	158.09	51.715	159.00	52.011	1.7653	1.110	.5684	.71888

# EMULSION (NTA)

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM2	PROTON PATH LENGTH CM	GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.9791	163.10	53.352	164.03	59.410	.5681	.71067
510.00	1.9636	168.14	55.003	169.10	61.081	.5679	.72116
520.00	1.9486	173.23	56.666	174.22	62.760	.5677	.73135
530.00	1.9343	178.35	58.341	179.37	64.448	.5674	.74126
540.00	1.9206	183.51	60.029	184.56	66.143	.5672	.75089
550.00	1.9074	188.70	61.729	189.78	67.846	.5669	.76023
560.00	1.8947	193.94	63.440	195.04	69.556	.5667	.76929
570.00	1.8825	199.20	65.163	200.34	71.273	.5664	.77808
580.00	1.8708	204.50	66.896	205.67	72.997	.5662	.78660
590.00	1.8595	209.83	68.640	211.03	74.727	.5659	.79484
600.00	1.8486	215.20	70.395	216.42	76.464	.5657	.80293
620.00	1.8280	226.02	73.934	227.30	79.956	.5652	.81804
640.00	1.8089	236.95	77.513	238.30	83.471	.5646	.83226
660.00	1.7910	248.01	81.126	249.41	87.009	.5641	.84553
680.00	1.7744	259.17	84.778	260.63	90.567	.5636	.85791
700.00	1.7588	270.42	88.461	271.96	94.144	.5630	.86942
720.00	1.7443	281.78	92.175	283.37	97.740	.5625	.88012
740.00	1.7307	293.24	95.925	294.90	101.35	.5619	.89004
760.00	1.7179	304.78	99.699	306.50	104.98	.5613	.89923
780.00	1.7059	316.40	103.50	318.18	108.63	.5607	.90773
800.00	1.6946	328.10	107.33	329.95	112.29	.5605	.91558
820.00	1.6840	339.88	111.18	341.79	115.96	.5600	.92282
840.00	1.6740	351.73	115.06	353.70	119.65	.5594	.92945
860.00	1.6646	363.65	118.95	365.69	123.35	.5588	.93562
880.00	1.6557	375.63	122.88	377.74	127.06	.5582	.94126
900.00	1.6474	387.67	126.82	389.85	130.78	.5575	.94645
920.00	1.6394	399.79	130.78	402.03	134.52	.5569	.95120
940.00	1.6319	412.00	134.77	414.30	138.26	.5561	.95556
960.00	1.6248	424.25	138.78	426.61	142.02	.5549	.95956
1000.00	1.6118	446.99	146.87	451.49	149.56	.5533	.96655

THE ELECTRON DENSITY OF EMULSION (NTA) IS 2.775E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.115 BEV, AND THE MINIMUM ENERGY LOSS IS 1.5031 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 248.55 ELECTRON VOLTS



ADJUSTED  
IONIZATION  
POTENTIAL

ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL
SI	14	1.0000	20.0470	28.086	170.0
O	8	6.1949	70.7450	15.999	98.50
B	5	.77210	5.9580	10.811	67.10
NA	11	.12401	2.0350	22.990	150.1
K	19	.00176	.0490	39.102	203.8
CA	20	.00259	.0740	40.080	211.3
AL	13	.02835	.5460	26.981	163.0
FE	26	.01370	.1560	55.847	273.0

DENSITY = 2.500 GH/CH3

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GH/CH2	MEV/CH	MG/CH2	MM	MG/CH2	MM	MG/CH2	MM			
.10	577.50	1443.7	.18181	.00073	.18355	.00073	.00744	.00003	4.054	.9503	0.
.15	554.54	1366.4	.26999	.00108	.27189	.00109	.00985	.00004	3.624	.6989	0.
.20	502.48	1256.2	.36435	.00146	.36655	.00147	.01218	.00005	3.323	.6016	0.
.30	419.14	1047.8	.58185	.00233	.58486	.00234	.01716	.00007	2.935	.5141	0.
.40	357.95	894.89	.83970	.00336	.84367	.00337	.02269	.00009	2.713	.4697	0.
.50	315.49	788.72	1.1368	.00455	1.1419	.00457	.02929	.00012	2.565	.4411	0.
.60	284.71	711.78	1.4697	.00588	1.4739	.00590	.03621	.00014	2.454	.4203	0.
.70	257.47	643.67	1.8376	.00738	1.8451	.00738	.04368	.00017	2.367	.4042	0.
.80	238.66	596.65	2.2398	.00896	2.2485	.00899	.05165	.00021	2.297	.3910	0.
.90	222.59	556.49	2.6719	.01069	2.6821	.01073	.05993	.00024	2.234	.3800	0.
1.00	206.51	516.27	3.1369	.01255	3.1486	.01259	.06866	.00027	2.181	.3703	0.
1.20	182.62	456.54	4.1656	.01666	4.1804	.01672	.08775	.00034	2.099	.3543	0.
1.40	164.26	413.64	5.3190	.02128	5.3373	.02135	.10876	.00044	2.038	.3420	0.
1.60	149.73	374.31	6.5925	.02637	6.6145	.02646	.13148	.00053	1.986	.3319	.00001
1.80	137.81	344.52	7.9633	.03193	8.0092	.03204	.15584	.00062	1.946	.3235	.00001
2.00	127.88	319.70	9.4862	.03794	9.5163	.03807	.18172	.00073	1.910	.3164	.00002
2.20	119.46	298.64	11.101	.04440	11.135	.04454	.20907	.00084	1.878	.3102	.00003
2.40	112.21	280.52	12.825	.05130	12.864	.05146	.23786	.00095	1.849	.3048	.00005
2.60	105.88	264.70	14.656	.05862	14.700	.05880	.26804	.00107	1.823	.3000	.00006
2.80	100.29	250.73	16.593	.06637	16.642	.06657	.29958	.00120	1.800	.2957	.00008
3.00	95.348	238.37	18.633	.07453	18.687	.07475	.33246	.00133	1.779	.2919	.00010
3.20	90.926	227.32	20.776	.08310	20.836	.08334	.36665	.00147	1.763	.2884	.00012
3.40	86.941	217.35	23.030	.09208	23.086	.09234	.40212	.00161	1.742	.2852	.00015
3.60	83.335	208.34	25.335	.10146	25.437	.10175	.43884	.00176	1.725	.2823	.00017
3.80	80.042	200.11	27.818	.11123	27.886	.11155	.47680	.00191	1.715	.2796	.00020
4.00	77.028	192.57	30.349	.12140	30.434	.12173	.51600	.00206	1.698	.2771	.00023
4.20	74.256	185.64	32.988	.13195	33.079	.13231	.55641	.00223	1.682	.2748	.00026
4.40	71.698	179.24	35.723	.14289	35.820	.14328	.59802	.00239	1.668	.2726	.00030
4.60	69.322	173.32	38.552	.15421	38.657	.15463	.64682	.00256	1.658	.2706	.00033
4.80	67.327	167.82	41.478	.16591	41.590	.16636	.68479	.00274	1.647	.2687	.00037

## GLASS (PYREX)

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH GM/CM <sup>2</sup>	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM <sup>2</sup>	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	65.076	162.69	0.4462	0.01785	0.0073	0.0029	1.636	0.0044
5.50	60.509	151.27	0.5259	0.02104	0.0085	0.0034	1.612	0.0075
6.00	56.600	141.50	0.6114	0.02439	0.0097	0.0039	1.591	0.0107
6.50	53.211	133.03	0.7026	0.02810	0.0110	0.0044	1.572	0.0141
7.00	50.243	125.61	0.7993	0.03197	0.0124	0.0050	1.555	0.0209
7.50	47.594	118.98	0.9016	0.03606	0.0139	0.0056	1.540	0.0365
8.00	45.263	113.16	1.0094	0.04037	0.0154	0.0062	1.524	0.0674
8.50	43.171	107.93	1.1224	0.04490	0.0170	0.0068	1.513	0.0839
9.00	41.282	103.21	1.2409	0.04964	0.0186	0.0075	1.501	0.1103
9.50	39.567	98.918	1.3647	0.05459	0.0203	0.0081	1.490	0.1320
10.00	38.002	95.006	1.4937	0.05975	0.0221	0.0088	1.480	0.1548
11.00	35.250	88.124	1.7671	0.07069	0.0258	0.0103	1.462	0.2003
12.00	32.904	82.259	2.0610	0.08244	0.0298	0.0119	1.445	0.2459
13.00	30.878	77.196	2.3749	0.09499	0.0340	0.0136	1.431	0.2917
14.00	29.111	72.777	2.7086	0.10834	0.0384	0.0154	1.418	0.3375
15.00	27.553	68.883	3.0618	0.12247	0.0431	0.0172	1.406	0.3834
16.00	26.170	65.425	3.4343	0.13737	0.0479	0.0192	1.395	0.4295
17.00	24.933	62.332	3.8260	0.15304	0.0530	0.0212	1.386	0.4735
18.00	23.819	59.547	4.2269	0.16946	0.0583	0.0233	1.376	0.5219
19.00	22.810	57.025	4.6556	0.18662	0.0638	0.0255	1.368	0.5682
20.00	21.822	54.730	5.1132	0.20453	0.0695	0.0278	1.360	0.6146
22.00	20.283	50.707	6.0631	0.22522	0.0816	0.0326	1.346	0.7077
24.00	18.916	47.289	7.0849	0.28340	0.0945	0.0378	1.333	0.8012
26.00	17.741	44.353	8.1773	0.32709	0.1081	0.0432	1.322	0.8983
28.00	16.719	41.798	9.3392	0.37357	0.1225	0.0490	1.312	0.9879
30.00	15.821	39.554	1.0569	0.42278	0.1376	0.0551	1.302	0.9982
32.00	15.026	37.563	1.1842	0.47468	0.1535	0.0614	1.294	0.9193
34.00	14.316	35.791	1.3231	0.52924	0.1701	0.0680	1.286	0.9410
36.00	13.679	34.197	1.4661	0.58643	0.1874	0.0750	1.278	0.9633
38.00	13.103	32.756	1.6155	0.64621	0.2054	0.0822	1.271	0.9862
40.00	12.579	31.448	1.7713	0.70853	0.2241	0.0896	1.265	1.0096
45.00	11.459	28.647	2.1884	0.87554	0.2736	0.1094	1.250	1.0697
50.00	10.546	26.364	2.6437	1.05553	0.3272	0.1309	1.238	1.1319
55.00	9.7863	24.463	3.1363	1.2545	0.3846	0.1538	1.226	1.1965
60.00	9.1445	22.861	3.6652	1.4661	0.4457	0.1783	1.218	1.2640
65.00	8.5946	21.487	4.2295	1.6918	0.5103	0.2041	1.210	1.3340
70.00	8.1178	20.295	4.8285	1.9314	0.5784	0.2314	1.198	1.4063
75.00	7.7004	19.251	5.4611	2.1845	0.6499	0.2600	1.190	1.4805
80.00	7.3317	18.329	6.1146	2.4458	0.7240	0.2898	1.183	1.5562
90.00	6.7095	16.774	7.5395	3.0133	0.8833	0.3533	1.169	1.7114

## GLASS (PYREX)

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GN/CH2	PROTON PATH LENGTH CH/CH2	PATH LENGTH STRAGGLING CH/CH2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	6.2046	15.511	9.1060	1.0538	1.157	.16695
110.00	5.7862	14.465	10.776	.04942	1.146	.20315
120.00	5.4338	13.584	12.561	.05711	1.137	.21974
130.00	5.1328	12.832	14.427	.06520	1.127	.23664
140.00	4.8726	12.182	16.456	.07366	1.119	.25372
150.00	4.6455	11.614	18.559	.08249	1.111	.27089
160.00	4.4455	11.114	20.760	.09166	1.104	.28815
170.00	4.2681	10.670	23.057	.10116	1.097	.30552
180.00	4.1096	10.274	25.443	.11097	1.090	.32293
190.00	3.9671	9.9178	27.922	.12108	1.084	.34031
200.00	3.8384	9.5960	30.486	.13147	1.076	.35762
210.00	3.7215	9.3032	33.132	.14213	1.072	.37483
220.00	3.6150	9.0375	35.859	.15305	1.067	.39194
230.00	3.5175	8.7937	38.664	.16422	1.062	.40892
240.00	3.4279	8.5697	41.544	.17562	1.057	.42572
250.00	3.3453	8.3632	44.497	.18725	1.052	.44231
260.00	3.2690	8.1724	47.522	.19910	1.047	.45872
270.00	3.1982	7.9954	50.615	.21116	1.043	.47497
280.00	3.1324	7.8309	53.775	.22342	1.038	.49104
290.00	3.0711	7.6777	56.999	.23587	1.035	.50689
300.00	3.0138	7.5346	60.286	.24851	1.031	.52252
310.00	2.9603	7.4007	63.635	.26132	1.027	.53792
320.00	2.9100	7.2751	67.042	.27430	1.023	.55312
330.00	2.8629	7.1572	70.507	.28745	1.019	.56808
340.00	2.8185	7.0462	74.028	.30076	1.016	.58281
350.00	2.7767	6.9416	77.602	.31421	1.012	.59728
360.00	2.7372	6.8429	81.230	.32782	1.009	.61151
370.00	2.6999	6.7497	84.909	.34156	1.006	.62554
380.00	2.6645	6.6614	88.637	.35544	1.003	.63935
390.00	2.6311	6.5777	92.414	.36945	.9995	.65292
400.00	2.5993	6.4983	96.238	.38359	.9965	.66624
410.00	2.5692	6.4229	100.11	.39785	.9934	.67924
420.00	2.5405	6.3512	104.02	.41223	.9907	.69186
430.00	2.5132	6.2829	107.98	.42672	.9880	.70411
440.00	2.4871	6.2179	111.98	.44132	.9853	.71598
450.00	2.4623	6.1558	116.02	.45603	.9826	.72748
460.00	2.4386	6.0966	120.10	.47084	.9801	.73862
470.00	2.4160	6.0400	124.22	.48575	.9776	.74939
480.00	2.3944	5.9856	128.38	.50076	.9751	.75979
490.00	2.3736	5.9341	132.57	.51586	.9728	.76985

## GLASS (PYREX)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
				GM/CM2	CH		
500.00	2.3538	5.8845	136.81	54.722	1.3276	.53105	.9704
510.00	2.3348	5.8370	141.07	56.429	1.3658	.54632	.9682
520.00	2.3166	5.7914	145.37	58.149	1.4042	.56168	.9659
530.00	2.2991	5.7477	149.70	59.882	1.4428	.57713	.9638
540.00	2.2823	5.7057	154.07	61.628	1.4816	.59255	.9617
550.00	2.2661	5.6653	158.18	63.387	1.5206	.60825	.9596
560.00	2.2503	5.6265	162.60	65.158	1.5598	.62393	.9576
570.00	2.2357	5.5892	167.05	66.942	1.5992	.63967	.9556
580.00	2.2213	5.5533	171.53	68.737	1.6387	.65549	.9536
590.00	2.2075	5.5187	176.03	70.543	1.6784	.67138	.9517
600.00	2.1942	5.4854	180.90	72.360	1.7183	.68733	.9499
620.00	2.1689	5.4223	189.72	75.289	1.7586	.71943	.9463
640.00	2.1454	5.3623	199.34	79.737	1.8794	.75177	.9426
660.00	2.1235	5.3088	208.33	83.333	1.9609	.78435	.9385
680.00	2.1031	5.2577	217.78	87.112	2.0429	.81714	.9363
700.00	2.0840	5.2099	227.32	91.092	2.1254	.85015	.9333
720.00	2.0661	5.1652	236.94	94.948	2.2084	.88335	.9303
740.00	2.0493	5.1232	246.64	98.836	2.2918	.91674	.9275
760.00	2.0335	5.0838	256.42	102.57	2.3758	.95031	.9248
780.00	2.0187	5.0467	266.28	106.51	2.4601	.98405	.9222
800.00	2.0048	5.0119	276.20	110.48	2.5449	1.0180	.9197
820.00	1.9916	4.9791	286.71	114.69	2.6300	1.0520	.9173
840.00	1.9793	4.9482	296.79	118.72	2.7156	1.0862	.9150
860.00	1.9676	4.9190	306.37	122.55	2.8014	1.1206	.9127
880.00	1.9566	4.8915	316.55	126.62	2.8877	1.1551	.9106
900.00	1.9462	4.8654	326.79	130.72	2.9742	1.1897	.9085
920.00	1.9363	4.8408	337.08	134.83	3.0611	1.2244	.9065
940.00	1.9270	4.8175	347.43	138.97	3.1493	1.2593	.9045
960.00	1.9182	4.7954	357.84	143.14	3.2357	1.2943	.9026
1000.00	1.9018	4.7545	378.88	151.55	3.4115	1.3646	.8988

THE ELECTRON DENSITY OF GLASS (PYREX) IS 2.93E 23 ELECTRONS PER GR4H

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.243 BEV, AND THE MINIMUM ENERGY LOSS IS 1.7414 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 109. ELECTRON VOLTS

ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL
C	6	16	74.163	12.011	77.30
H	1	19	7.3650	1.0080	18.29
O	8	3.	13.5087	15.999	98.50

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GH/CH2	MEV/CM	MG/CH2	MM	MG/CH2	MM	MG/CM2	MM			
.10	979.93	1175.5	.12472	.00104	.12546	.00105	.60522	.00004	4.158	.5920	0.
.15	852.40	1022.9	.17933	.00149	.18012	.00150	.8642	.00005	3.563	.4408	0.
.20	743.84	892.60	.24197	.00202	.24287	.00202	.10780	.00007	3.212	.3722	0.
.30	589.55	707.46	.39330	.00328	.39451	.00329	.01123	.00009	2.846	.3079	0.
.40	489.41	587.29	.57973	.00483	.58134	.00484	.01555	.00013	2.674	.2773	0.
.50	421.51	505.81	.79994	.00667	.80202	.00668	.02059	.00017	2.567	.2591	0.
.60	373.03	447.64	1.0520	.00877	1.0546	.00879	.02316	.00022	2.408	.2469	0.
.70	335.78	402.93	1.3339	.01112	1.3371	.01114	.02519	.00027	2.360	.2380	0.
.80	305.26	366.32	1.6456	.01371	1.6494	.01375	.03872	.00032	2.347	.2310	0.
.90	282.62	339.14	1.9051	.01654	1.9096	.01658	.04563	.00038	2.294	.2255	0.
1.00	259.95	311.94	2.3534	.01941	2.3586	.01965	.05302	.00044	2.248	.2207	0.
1.20	228.52	274.22	3.1741	.02645	3.1809	.02651	.06915	.00058	2.174	.2132	0.
1.40	204.67	245.61	4.0988	.03416	4.1073	.03423	.08666	.00072	2.110	.2075	0.
1.60	185.85	223.02	5.1241	.04270	5.1345	.04279	.10550	.00088	2.055	.2029	.00001
1.80	170.55	204.66	6.2469	.05206	6.2594	.05216	.12565	.00105	2.007	.1989	.00002
2.00	157.84	189.40	7.4646	.06221	7.4792	.06233	.14706	.00123	1.966	.1936	.00003
2.20	147.07	176.49	8.7755	.07313	8.7925	.07327	.16971	.00141	1.930	.1927	.00004
2.40	137.82	165.39	10.179	.08482	10.198	.08499	.19359	.00161	1.898	.1900	.00006
2.60	129.78	155.74	11.673	.09727	11.695	.09745	.21866	.00182	1.870	.1877	.00007
2.80	122.72	147.26	13.255	.11046	13.280	.11067	.24491	.00204	1.844	.1856	.00010
3.00	116.46	139.73	14.926	.12438	14.953	.12461	.27232	.00227	1.821	.1837	.00012
3.20	110.86	133.03	16.684	.13903	16.714	.13929	.30088	.00251	1.800	.1820	.00015
3.40	105.83	127.00	18.528	.15440	18.561	.15468	.33058	.00275	1.781	.1804	.00017
3.60	101.28	121.54	20.457	.17048	20.494	.17078	.36139	.00301	1.763	.1789	.00021
3.80	97.140	116.57	22.471	.18726	22.511	.18759	.39331	.00326	1.747	.1775	.00024
4.00	93.356	112.03	24.568	.20474	24.611	.20509	.42632	.00355	1.732	.1762	.00027
4.20	89.764	107.72	26.751	.22292	26.798	.22331	.46054	.00384	1.719	.1750	.00031
4.40	86.581	103.90	29.017	.24181	29.068	.24223	.49585	.00413	1.706	.1739	.00035
4.60	83.636	100.36	31.351	.26135	31.416	.26180	.53220	.00443	1.694	.1728	.00039
4.80	80.904	97.084	33.792	.28160	33.850	.28208	.56958	.00475	1.683	.1718	.00044

REACTION ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH GM/CM <sup>2</sup>	CM/CM <sup>2</sup>	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	78.360	94.031	.03630	.03030	.00061	1.672	.00048
5.50	72.705	87.246	.04292	.03587	.00071	1.648	.00061
6.00	67.877	81.452	.05003	.04176	.00082	1.627	.00201
6.50	63.702	76.442	.05763	.04810	.00093	1.608	.00400
7.00	60.052	72.063	.06570	.05484	.00105	1.591	.00619
7.50	56.823	68.180	.07425	.06198	.00117	1.576	.00852
8.00	53.963	64.756	.08327	.06950	.00130	1.563	.01085
8.50	51.401	61.622	.09275	.07729	.00144	1.550	.01318
9.00	49.093	58.911	.10269	.08572	.00150	1.539	.01551
9.50	47.001	56.401	.11309	.09424	.00173	1.528	.01784
10.00	45.095	54.115	.12394	.10326	.00188	1.518	.02017
11.00	41.751	50.101	.14697	.12248	.00221	1.501	.02482
12.00	38.908	46.690	.17176	.14314	.00255	1.475	.02948
13.00	36.465	43.752	.19829	.16524	.00292	1.471	.03415
14.00	34.328	41.194	.22653	.18878	.00331	1.459	.03882
15.00	32.454	38.945	.25684	.21372	.00372	1.447	.04350
16.00	30.792	36.950	.28806	.24041	.00415	1.437	.04819
17.00	29.307	35.169	.32179	.26816	.00459	1.428	.05288
18.00	27.973	33.567	.35673	.29736	.00506	1.419	.05753
19.00	26.766	32.119	.39271	.32774	.00555	1.411	.06230
20.00	25.669	30.803	.43081	.35954	.00605	1.403	.06701
22.00	23.749	28.499	.51177	.42710	.00712	1.390	.07646
24.00	22.123	26.547	.59897	.49986	.00826	1.377	.08593
26.00	20.726	24.872	.69230	.57775	.00947	1.366	.09163
28.00	19.513	23.416	.79167	.65972	.01075	1.356	.09342
30.00	18.449	22.139	.89698	.74749	.01210	1.347	.09529
32.00	17.508	21.009	1.0082	.84033	.01352	1.339	.09722
34.00	16.668	20.002	1.1251	.93892	.01500	1.331	.09921
36.00	15.915	19.098	1.2478	1.0398	.01654	1.324	.10125
38.00	15.235	18.282	1.3761	1.1467	.01815	1.317	.10335
40.00	14.618	17.542	1.5100	1.2583	.01982	1.311	.10548
45.00	13.299	15.959	1.8711	1.5593	.02426	1.296	.11097
50.00	12.226	14.671	2.2606	1.8833	.02906	1.284	.11663
55.00	11.335	13.602	2.6851	2.2376	.03422	1.273	.12249
60.00	10.583	12.699	3.1414	2.6178	.03971	1.262	.12861
65.00	9.9387	11.920	3.6335	3.0238	.04553	1.253	.13495
70.00	9.3810	11.257	4.1460	3.4550	.05166	1.244	.14149
75.00	8.8931	10.672	4.6993	3.9161	.05610	1.236	.14818
80.00	8.4625	10.153	5.2758	4.3965	.06084	1.229	.15500
90.00	7.7368	9.2842	6.5133	5.4278	.07917	1.215	.16894

## LEXAN

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE CM	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
GH/CM2	MEV/CM	GH/CM2	GH/CM2	GH/CM2	PERCENT	
100.00	7.1484	8.5781	7.8594	6.5495	.09458	.18308
110.00	6.6614	7.9937	9.3098	7.7582	.11101	.19752
120.00	6.2516	7.5019	10.846	9.0504	.12892	.21237
130.00	5.9018	7.0822	12.508	10.423	.14674	.22755
140.00	5.5997	6.7196	14.230	11.873	.16593	.24295
150.00	5.3361	6.4034	16.078	13.399	.18555	.25848
160.00	5.1042	6.1250	17.995	14.996	.20676	.27515
170.00	4.8984	5.8782	19.970	16.663	.22832	.29998
180.00	4.7147	5.6576	22.049	18.398	.25080	.30590
190.00	4.5496	5.4596	24.206	20.197	.27356	.32186
200.00	4.4006	5.2807	26.439	22.060	.29717	.33781
210.00	4.2653	5.1183	28.744	23.984	.32141	.35373
220.00	4.1417	4.9700	31.121	25.967	.34624	.36961
230.00	4.0288	4.8345	33.567	28.008	.37165	.38541
240.00	3.9251	4.7101	36.078	30.103	.39761	.40108
250.00	3.8295	4.5954	38.704	32.253	.42408	.41662
260.00	3.7411	4.4893	41.343	34.455	.45107	.43200
270.00	3.6592	4.3910	44.049	36.708	.47853	.44723
280.00	3.5830	4.2996	46.811	39.009	.50646	.46229
290.00	3.5121	4.2145	49.568	41.359	.53483	.47716
300.00	3.4459	4.1350	52.439	43.754	.56363	.49182
310.00	3.3839	4.0606	55.365	46.195	.59284	.50637
320.00	3.3257	3.9909	58.342	48.680	.62245	.52040
330.00	3.2711	3.9254	61.448	51.206	.65244	.53508
340.00	3.2198	3.8637	64.448	53.774	.68279	.54921
350.00	3.1714	3.8056	67.574	56.382	.71350	.56316
360.00	3.1257	3.7508	70.747	59.029	.74454	.57699
370.00	3.0825	3.6990	73.965	61.714	.77591	.59075
380.00	3.0416	3.6499	77.227	64.436	.80760	.60442
390.00	3.0028	3.6034	80.532	67.193	.83960	.61799
400.00	2.9661	3.5593	83.878	69.986	.87188	.63142
410.00	2.9311	3.5174	87.266	72.812	.90445	.64462
420.00	2.8979	3.4775	90.693	75.671	.93729	.65750
430.00	2.8663	3.4396	94.159	78.563	.97040	.67005
440.00	2.8362	3.4034	97.662	81.486	1.0038	.68227
450.00	2.8074	3.3689	101.20	84.439	1.0374	.69416
460.00	2.7800	3.3360	104.78	87.422	1.0712	.70572
470.00	2.7538	3.3045	108.39	90.434	1.1053	.71695
480.00	2.7287	3.2744	112.03	93.474	1.1396	.72786
490.00	2.7047	3.2456	115.71	96.542	1.1741	.73844

LEXAN

PROTON ENERGY PEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
500.00	2.6817	3.2189	99.514	119.56	99.636	1.2089	1.0074	1.011	.74870
510.00	2.6597	3.1916	102.63	123.31	102.76	1.2438	1.0365	1.009	.75865
520.00	2.6385	3.1662	105.77	127.08	105.90	1.2789	1.0658	1.006	.76829
530.00	2.6182	3.1419	108.94	130.89	109.07	1.3142	1.0952	1.004	.77763
540.00	2.5988	3.1185	112.13	134.72	112.27	1.3498	1.1248	1.002	.78668
550.00	2.5800	3.0961	115.35	138.58	115.49	1.3854	1.1545	.9997	.79543
560.00	2.5620	3.0745	118.58	142.47	118.73	1.4213	1.1844	.9976	.80389
570.00	2.5447	3.0537	121.84	146.39	121.99	1.4573	1.2144	.9955	.81207
580.00	2.5281	3.0337	125.12	150.33	125.28	1.4935	1.2446	.9935	.81998
590.00	2.5120	3.0144	128.43	154.30	128.58	1.5299	1.2749	.9915	.82761
600.00	2.4965	2.9958	131.75	158.29	131.91	1.5664	1.3053	.9895	.83497
620.00	2.4672	2.9607	138.46	166.35	138.63	1.6398	1.3665	.9858	.84892
640.00	2.4400	2.9279	145.24	174.51	145.42	1.7139	1.4282	.9821	.86188
660.00	2.4145	2.8974	152.10	182.74	152.29	1.7884	1.4904	.9787	.87390
680.00	2.3907	2.8689	159.03	191.07	159.22	1.8635	1.5529	.9753	.88503
700.00	2.3685	2.8422	166.03	199.47	166.23	1.9391	1.6159	.9721	.89531
720.00	2.3477	2.8172	173.09	207.96	173.30	2.0151	1.6793	.9690	.90479
740.00	2.3281	2.7937	180.21	216.51	180.43	2.0916	1.7430	.9660	.91351
760.00	2.3090	2.7717	187.39	225.14	187.61	2.1685	1.8070	.9632	.92153
780.00	2.2925	2.7510	194.63	233.83	194.86	2.2457	1.8714	.9604	.92887
800.00	2.2762	2.7315	201.91	242.59	202.15	2.3234	1.9362	.9578	.93557
820.00	2.2609	2.7131	209.25	251.40	209.50	2.4014	2.0012	.9552	.94169
840.00	2.2465	2.6958	216.64	260.28	216.90	2.4798	2.0665	.9527	.94727
860.00	2.2328	2.6794	224.08	269.21	224.34	2.5585	2.1321	.9504	.95235
880.00	2.2199	2.6639	231.56	277.87	231.83	2.6375	2.1979	.9481	.95697
900.00	2.2078	2.6493	239.08	286.90	239.36	2.7168	2.2640	.9458	.96117
920.00	2.1962	2.6355	246.65	295.97	246.94	2.7964	2.3303	.9437	.96498
940.00	2.1853	2.6224	254.25	305.46	254.55	2.8763	2.3969	.9416	.96844
960.00	2.1750	2.6099	261.90	314.28	262.21	2.9565	2.4637	.9396	.97158
1000.00	2.1558	2.5870	277.37	332.85	277.70	3.1172	2.5980	.9355	.97700

THE ELECTRON DENSITY OF LEXAN IS 3.229E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.319 BEV, AND THE MINIMUM ENERGY LOSS IS 1.9799 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 66.19 ELECTRON VOLTS



# LITHIUM FLUORIDE

FRCION ENERGY MEV	ENERGY LOSS NEV/ GM/CM2	PROTON RANGE MG/CM2 MM	PROTON PATH LENGTH MG/CM2 MM	ATOMS/ MOLECULE 1 1	PERCENT BY WEIGHT 26.7529 73.2471	ATOMIC WEIGHT 6.9390 18.998	ADJUSTED IONIZATION POTENTIAL 38.80 120.7	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	640.37	1665.6	18178	.00070	.18322	.00070	.00669	.00003	3.651
.15	573.53	1491.7	26413	.00102	.26568	.00102	.00854	.00003	3.215
.20	514.98	1339.5	35586	.00137	.35754	.00138	.01048	.00004	2.931
.30	422.62	1099.2	57014	.00219	.57254	.00220	.01487	.00006	2.596
.40	358.42	932.26	82708	.00318	.83023	.00319	.02017	.00008	2.430
.50	314.55	818.13	111247	.00432	1.1287	.00434	.02644	.00010	2.343
.60	284.02	738.73	14639	.00561	1.4639	.00563	.03326	.00013	2.272
.70	261.57	680.35	18350	.00702	1.8350	.00704	.04036	.00016	2.204
.80	241.59	628.38	22216	.00854	2.2216	.00857	.04772	.00018	2.142
.90	224.09	582.87	26500	.01019	2.6500	.01022	.05562	.00021	2.092
1.00	206.58	537.31	31136	.01197	3.1129	.01201	.06437	.00025	2.061
1.20	181.83	472.93	41452	.01594	4.1570	.01598	.08394	.00032	2.019
1.40	163.07	424.16	53059	.02040	5.3205	.02046	.10525	.00040	1.978
1.60	148.24	385.58	65913	.02534	6.6089	.02541	.12816	.00049	1.939
1.80	136.16	354.16	79975	.03075	8.0184	.03083	.15264	.00059	1.904
2.00	126.10	328.00	95215	.03661	9.5458	.03670	.17864	.00069	1.871
2.20	117.59	305.85	11161	.04291	11.189	.04302	.20611	.00079	1.842
2.40	110.28	286.83	12915	.04965	12.947	.04978	.23502	.00090	1.815
2.60	103.92	270.30	14780	.05683	14.816	.05696	.26533	.00102	1.791
2.80	98.340	255.78	16755	.06442	16.795	.06457	.29701	.00114	1.768
3.00	93.393	242.92	18838	.07243	18.883	.07260	.33004	.00127	1.748
3.20	88.974	231.42	21029	.08085	21.077	.08104	.36440	.00140	1.729
3.40	84.990	221.08	23324	.08967	23.378	.08988	.40005	.00154	1.711
3.60	81.402	211.73	25725	.09890	25.784	.09913	.43699	.00168	1.695
3.80	78.125	203.21	28228	.10853	28.292	.10877	.47519	.00183	1.680
4.00	75.137	195.43	30834	.11854	30.902	.11881	.51464	.00198	1.665
4.20	72.390	188.29	33541	.12895	33.615	.12924	.55533	.00214	1.652
4.40	69.857	181.70	36348	.13975	36.428	.14005	.59724	.00230	1.640
4.60	67.513	175.60	39255	.15092	39.341	.15125	.64036	.00246	1.628
4.80	65.338	169.94	42261	.16248	42.353	.16283	.68468	.00263	1.617

DENSITY = 2.6010 GM/CM3

LITHIUM FLUORIDE

PRCTON ENERGY HEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING		PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	HEV/ GM/CM2	HEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM	PERCENT	PERCENT	
5.00	63.313	164.68	.04536	.01744	.04546	.01748	.00073	.00028	1.606	.2149	.00475
5.50	58.809	152.96	.05355	.02059	.05366	.02063	.00085	.00033	1.582	.2118	.00632
6.00	54.960	142.95	.06233	.02397	.06246	.02402	.00098	.00037	1.561	.2090	.00789
6.50	51.629	134.29	.07171	.02757	.07186	.02763	.00111	.00043	1.542	.2065	.00946
7.00	48.714	126.71	.08166	.03140	.08183	.03146	.00125	.00048	1.526	.2043	.01104
7.50	46.140	120.01	.09219	.03545	.09238	.03552	.00140	.00054	1.511	.2024	.01383
8.00	43.850	114.05	.10329	.03971	.10350	.03979	.00155	.00060	1.497	.2006	.01685
8.50	41.796	108.71	.11495	.04420	.11518	.04428	.00171	.00066	1.484	.1990	.01987
9.00	39.944	103.90	.12717	.04889	.12742	.04899	.00188	.00072	1.473	.1975	.02287
9.50	38.241	99.464	.13994	.05380	.14022	.05391	.00205	.00079	1.462	.1961	.02588
10.00	36.714	95.493	.15326	.05892	.15356	.05904	.00223	.00086	1.452	.1949	.02888
11.00	34.030	88.513	.18154	.06979	.18189	.06993	.00261	.00100	1.434	.1926	.03486
12.00	31.745	82.569	.21192	.08148	.21232	.08163	.00301	.00116	1.419	.1906	.04084
13.00	29.774	77.442	.24441	.09397	.24488	.09415	.00344	.00132	1.405	.1889	.04681
14.00	28.055	72.972	.27897	.10725	.27949	.10746	.00389	.00150	1.392	.1874	.05277
15.00	26.542	69.036	.31556	.12132	.31615	.12155	.00437	.00168	1.381	.1860	.05872
16.00	25.199	65.542	.35418	.13617	.35483	.13642	.00486	.00187	1.371	.1847	.06467
17.00	23.998	62.418	.39479	.15178	.39551	.15206	.00538	.00207	1.361	.1836	.07061
18.00	22.917	59.608	.43737	.16815	.43817	.16846	.00593	.00228	1.352	.1825	.07656
19.00	21.939	57.065	.48190	.18528	.48278	.18561	.00649	.00249	1.344	.1815	.08249
20.00	21.050	54.751	.52836	.20314	.52932	.20351	.00707	.00272	1.337	.1807	.08942
22.00	19.492	50.698	.62701	.24107	.62814	.24150	.00831	.00319	1.323	.1791	.10028
24.00	18.170	47.260	.73318	.28189	.73449	.28239	.00963	.00370	1.311	.1776	.11211
26.00	17.034	44.305	.84675	.32555	.84824	.32612	.01102	.00424	1.300	.1764	.11916
28.00	16.046	41.736	.96758	.37200	.96928	.37266	.01250	.00481	1.290	.1753	.12132
30.00	15.179	39.481	1.0956	.42121	1.0975	.42195	.01406	.00540	1.281	.1743	.12355
32.00	14.411	37.484	1.2306	.47314	1.2328	.47396	.01569	.00603	1.273	.1734	.12586
34.00	13.726	35.702	1.3726	.52773	1.3750	.52865	.01739	.00669	1.265	.1726	.12823
36.00	13.111	34.103	1.5215	.58498	1.5241	.58598	.01917	.00737	1.258	.1718	.13067
38.00	12.556	32.658	1.6772	.64483	1.6801	.64593	.02102	.00808	1.251	.1712	.13315
40.00	12.052	31.347	1.8395	.70724	1.8427	.70845	.02294	.00882	1.245	.1705	.13568
45.00	10.972	28.539	2.2742	.87436	2.2781	.87584	.02804	.01078	1.231	.1691	.14218
50.00	10.094	26.253	2.7491	1.0569	2.7537	1.0587	.03356	.01290	1.219	.1679	.14883
55.00	9.3633	24.354	3.2630	1.2545	3.2684	1.2566	.03947	.01518	1.208	.1669	.15571
60.00	8.7463	22.749	3.8150	1.4668	3.8214	1.4692	.04577	.01760	1.198	.1660	.16289
65.00	8.2179	21.373	4.4042	1.6933	4.4115	1.6961	.05244	.02016	1.189	.1652	.17035
70.00	7.7599	20.183	5.0296	1.9337	5.0379	1.9369	.05947	.02286	1.180	.1645	.17803
75.00	7.3590	19.141	5.6905	2.1878	5.6999	2.1914	.06635	.02570	1.173	.1639	.18591
80.00	7.0051	18.220	6.3861	2.4552	6.3965	2.4593	.07456	.02867	1.166	.1633	.19395
90.00	6.4082	16.663	7.8782	3.0289	7.8910	3.0338	.09096	.03497	1.153	.1623	.21040

LITHIUM FLUORIDE

PRCTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH GM/CM2		PATH LENGTH STRAGGLING GM/CM2		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
100.00	5.9239	9.5004	3.6526	9.5158	3.6585	.10859	.04175	1.141	.22714
110.00	5.5228	11.247	4.3243	11.266	4.3312	.12737	.04897	1.131	.24427
120.00	5.1851	13.115	5.0421	13.136	5.0502	.14726	.05662	1.121	.26192
130.00	4.8955	15.097	5.8044	15.121	5.8136	.16819	.06466	1.112	.27997
140.00	4.6462	17.192	6.6096	17.219	6.6201	.19012	.07309	1.104	.29830
150.00	4.4287	19.394	7.4563	19.425	7.4682	.21299	.08189	1.096	.31682
160.00	4.2371	21.699	8.3427	21.734	8.3559	.23675	.09102	1.089	.33544
170.00	4.0672	24.106	9.2679	24.144	9.2825	.26137	.10049	1.083	.35408
180.00	3.9154	26.608	10.230	26.650	10.246	.28680	.11027	1.076	.37266
190.00	3.7790	29.205	11.228	29.251	11.246	.31301	.12034	1.070	.39113
200.00	3.6557	31.892	12.261	31.942	12.281	.33996	.13070	1.064	.40941
210.00	3.5439	34.666	13.328	34.721	13.349	.36762	.14134	1.059	.42737
220.00	3.4419	37.526	14.427	37.584	14.450	.39596	.15223	1.054	.44486
230.00	3.3485	40.467	15.558	40.530	15.583	.42495	.16338	1.048	.46186
240.00	3.2627	43.489	16.720	43.557	16.746	.45456	.17476	1.044	.47833
250.00	3.1837	46.587	17.911	46.660	17.939	.48476	.18638	1.039	.49427
260.00	3.1106	49.760	19.131	49.838	19.161	.51554	.19821	1.034	.50981
270.00	3.0428	53.006	20.379	53.088	20.411	.54687	.21025	1.030	.52512
280.00	2.9798	56.322	21.654	56.409	21.688	.57873	.22250	1.026	.54016
290.00	2.9211	59.708	22.956	59.800	22.991	.61109	.23494	1.022	.55493
300.00	2.8663	63.158	24.282	63.256	24.320	.64393	.24757	1.018	.56939
310.00	2.8150	66.674	25.634	66.777	25.674	.67725	.26038	1.014	.58373
320.00	2.7669	70.252	27.010	70.360	27.051	.71101	.27336	1.011	.59810
330.00	2.7217	73.891	28.408	74.004	28.452	.74521	.28651	1.007	.61246
340.00	2.6792	77.588	29.830	77.708	29.876	.77983	.29982	1.004	.62679
350.00	2.6391	81.344	31.274	81.469	31.322	.81485	.31328	1.000	.64105
360.00	2.6013	85.155	32.739	85.285	32.789	.85025	.32689	.9969	.65517
370.00	2.5655	89.020	34.225	89.156	34.278	.88603	.34065	.9938	.66969
380.00	2.5317	92.938	35.732	93.080	35.786	.92217	.35454	.9907	.68279
390.00	2.4996	96.908	37.258	97.056	37.315	.95865	.36857	.9877	.69625
400.00	2.4692	100.93	38.803	101.08	38.863	.99547	.38273	.9848	.70946
410.00	2.4403	105.00	40.367	105.16	40.429	1.0326	.39701	.9820	.72230
420.00	2.4128	109.11	41.940	109.28	42.013	1.0701	.41141	.9792	.73476
430.00	2.3866	113.27	43.549	113.44	43.616	1.1078	.42593	.9765	.74666
440.00	2.3616	117.48	45.166	117.66	45.235	1.1459	.44056	.9739	.75818
450.00	2.3370	121.73	46.800	121.91	46.871	1.1842	.45530	.9714	.76927
460.00	2.3151	126.02	48.450	126.21	48.524	1.2228	.47014	.9689	.77994
470.00	2.2934	130.35	50.116	130.55	50.193	1.2617	.48508	.9664	.79020
480.00	2.2727	134.73	51.798	134.93	51.877	1.3008	.50013	.9641	.80066
490.00	2.2528	139.14	53.495	139.35	53.576	1.3402	.51527	.9618	.80952

# LITHIUM FLUORIDE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.2338	5.8100	143.59	55.204	1.3798	.53050	.1513	.81859
510.00	2.2155	5.7625	148.08	56.932	1.4197	.54582	.1512	.82730
520.00	2.1980	5.7170	152.60	58.672	1.4598	.56123	.1510	.83563
530.00	2.1812	5.6734	157.17	60.425	1.5001	.57673	.1509	.84362
540.00	2.1651	5.6314	161.76	62.192	1.5406	.59230	.1507	.85126
550.00	2.1496	5.5911	166.39	63.971	1.5813	.60796	.1506	.85857
560.00	2.1347	5.5523	171.05	65.763	1.6222	.62369	.1505	.86555
570.00	2.1204	5.5151	175.74	67.568	1.6633	.63949	.1503	.87223
580.00	2.1066	5.4792	180.47	69.385	1.7046	.65537	.1502	.87861
590.00	2.0933	5.4446	185.22	71.213	1.7461	.67132	.1500	.88469
600.00	2.0805	5.4113	190.01	73.053	1.7878	.68734	.1499	.89050
620.00	2.0562	5.3482	199.67	76.765	1.8716	.71958	.1496	.90133
640.00	2.0336	5.2895	209.43	80.520	1.9561	.75207	.1493	.91116
660.00	2.0126	5.2347	219.31	84.316	2.0413	.78480	.1491	.92007
680.00	1.9929	5.1835	229.28	88.150	2.1270	.81776	.1488	.92815
700.00	1.9745	5.1356	239.35	92.021	2.2133	.85093	.1485	.93545
720.00	1.9572	5.0908	249.51	95.927	2.3001	.88431	.1482	.94205
740.00	1.9411	5.0487	259.75	99.867	2.3874	.91789	.1480	.94861
760.00	1.9259	5.0092	270.08	103.84	2.4753	.95166	.1477	.95337
780.00	1.9116	4.9720	280.49	107.84	2.5635	.98560	.1474	.95821
800.00	1.8981	4.9370	290.98	111.87	2.6523	1.0197	.1471	.96256
820.00	1.8854	4.9040	301.54	115.93	2.7414	1.0540	.1469	.96647
840.00	1.8735	4.8729	312.17	120.02	2.8310	1.0884	.1466	.96998
860.00	1.8622	4.8436	322.86	124.13	2.9210	1.1230	.1463	.97314
880.00	1.8515	4.8159	333.62	128.27	3.0113	1.1578	.1461	.97597
900.00	1.8415	4.7896	344.44	132.43	3.1020	1.1926	.1458	.97851
920.00	1.8319	4.7648	355.32	136.61	3.1931	1.2276	.1455	.98078
940.00	1.8229	4.7413	366.26	140.82	3.2845	1.2628	.1452	.98282
960.00	1.8143	4.7190	377.27	145.05	3.3762	1.2980	.1448	.98464
1000.00	1.7985	4.6779	399.52	153.60	3.5605	1.3689	.1440	.98775

THE ELECTRON DENSITY OF LITHIUM FLUORIDE IS 2.787E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.272 BEV, AND THE MINIMUM ENERGY LOSS IS 1.6466 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 90.88 ELECTRON VOLTS

# LUCITE

ADJUSTED  
IONIZATION  
POTENTIAL

ATOMIC  
WEIGHT

PERCENT  
BY WEIGHT

ATOMS/  
MOLECULE

ATOMIC  
NUMBER

ELEMENT

C 6  
H 1  
O 8

77.30  
18.30  
98.50

12.011  
1.0080  
15.999

59.9848  
8.0542  
31.9610

DENSITY = 1.2000 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE MM	PATH LENGTH MM	PROTON PATH LENGTH MM	MG/CM2	PATH LENGTH STRAGGLING MM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	969.18	1163.0	.00102	.12342	.00103	.00528	.00004	4.276	.5983
.15	850.26	1020.3	.00148	.17846	.00149	.00661	.00006	3.702	.4436
.20	742.70	871.34	.00200	.24133	.00201	.00804	.00007	3.331	.3750
.30	589.94	707.93	.00326	.39302	.00328	.01152	.00010	2.930	.3115
.40	490.18	588.21	.00482	.57962	.00483	.01592	.00013	2.746	.2815
.50	422.50	507.00	.00655	.79988	.00667	.02106	.00018	2.633	.2636
.60	374.30	449.16	.00874	1.0517	.00876	.02672	.00022	2.541	.2516
.70	336.84	404.21	.01108	1.3333	.01111	.03206	.00027	2.465	.2428
.80	306.79	368.14	.01367	1.6444	.01370	.03948	.00033	2.401	.2359
.90	284.01	340.31	.01649	1.9828	.01652	.04647	.00039	2.344	.2303
1.00	261.21	313.45	.01954	2.3501	.01958	.05395	.00045	2.296	.2256
1.20	229.54	275.44	.02635	3.1685	.02640	.07030	.00059	2.219	.2180
1.40	205.51	246.62	.03402	4.0910	.03409	.08807	.00073	2.153	.2123
1.60	186.56	223.87	.04293	5.1142	.04262	.10720	.00089	2.096	.2076
1.80	171.17	205.40	.05185	6.2439	.05196	.12735	.00106	2.047	.2036
2.00	158.33	190.06	.06196	7.4595	.06209	.14939	.00124	2.005	.2002
2.20	147.56	177.08	.07285	8.7592	.07299	.17239	.00144	1.968	.1973
2.40	138.28	165.93	.08451	10.160	.08467	.19662	.00164	1.935	.1946
2.60	130.20	156.25	.09691	11.652	.09710	.22205	.00185	1.906	.1923
2.80	123.11	147.74	.11006	13.232	.11027	.24867	.00207	1.879	.1902
3.00	116.83	140.20	.12394	14.900	.12417	.27645	.00230	1.855	.1882
3.20	111.22	133.46	.13854	16.655	.13879	.30540	.00254	1.834	.1865
3.40	106.17	127.41	.15385	18.496	.15414	.33547	.00280	1.814	.1848
3.60	101.61	121.93	.16988	20.423	.17019	.36667	.00306	1.795	.1834
3.80	97.456	116.95	.18660	22.433	.18694	.39899	.00332	1.779	.1819
4.00	93.662	112.39	.20402	24.527	.20439	.43240	.00360	1.763	.1806
4.20	90.083	108.10	.22215	26.706	.22255	.46699	.00389	1.749	.1794
4.40	86.888	104.27	.24097	28.968	.24140	.50267	.00419	1.735	.1783
4.60	83.933	100.72	.26044	31.308	.26090	.53941	.00450	1.723	.1772
4.80	81.190	97.428	.28061	33.733	.28111	.57718	.00481	1.711	.1762

LUCITE

PRCTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON LENGTH PATH LENGTH GM/CM2	CH	GM/CM2	CH	PERCENT	PATH LENGTH STRAGGLING CH	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	78.637	94.365	.03617	.03014	.03624	.03020	.00062	.00051	1.700	.1753	.00045
5.50	72.964	87.557	.04277	.03564	.04284	.03570	.00072	.00060	1.675	.1731	.00057
6.00	68.120	81.744	.04985	.04155	.04994	.04162	.00083	.00069	1.653	.1712	.00172
6.50	63.932	76.718	.05742	.04785	.05752	.04793	.00094	.00078	1.633	.1694	.00335
7.00	60.271	72.325	.06547	.05456	.06558	.05463	.00106	.00088	1.616	.1679	.00533
7.50	57.024	68.429	.07399	.06166	.07411	.06176	.00119	.00099	1.600	.1665	.00755
8.00	54.157	64.988	.08297	.06915	.08311	.06926	.00132	.00110	1.586	.1653	.00978
8.50	51.588	61.906	.09242	.07702	.09257	.07714	.00146	.00121	1.573	.1641	.01201
9.00	49.273	59.128	.10233	.08527	.10249	.08541	.00160	.00133	1.561	.1630	.01423
9.50	47.175	56.610	.11269	.09391	.11287	.09406	.00175	.00146	1.550	.1620	.01646
10.00	45.264	54.317	.12349	.10291	.12369	.10308	.00190	.00159	1.540	.1611	.01868
11.00	41.909	50.291	.14644	.12203	.14667	.12223	.00223	.00186	1.521	.1595	.02314
12.00	39.058	46.870	.17113	.14261	.17141	.14284	.00258	.00215	1.505	.1580	.02760
13.00	36.602	43.923	.19756	.16463	.19787	.16489	.00295	.00246	1.490	.1567	.03207
14.00	34.463	41.356	.22569	.18807	.22604	.18837	.00334	.00278	1.477	.1555	.03654
15.00	32.582	39.099	.25550	.21291	.25589	.21324	.00375	.00313	1.466	.1545	.04102
16.00	30.915	37.098	.28697	.23914	.28741	.23951	.00418	.00349	1.455	.1535	.04551
17.00	29.425	35.310	.32009	.26674	.32058	.26715	.00463	.00386	1.445	.1527	.05002
18.00	28.086	33.703	.35484	.29570	.35538	.29615	.00510	.00425	1.436	.1519	.05452
19.00	26.875	32.250	.39119	.32599	.39178	.32649	.00559	.00456	1.428	.1511	.05904
20.00	25.774	30.929	.42914	.35762	.42979	.35816	.00610	.00509	1.420	.1504	.06357
22.00	23.847	28.617	.50977	.42481	.51053	.42544	.00718	.00598	1.406	.1492	.07264
24.00	22.215	26.658	.59660	.49717	.59749	.49791	.00832	.00694	1.393	.1481	.08174
26.00	20.813	24.976	.68954	.57462	.69056	.57546	.00954	.00795	1.382	.1472	.08723
28.00	19.596	23.515	.78849	.65707	.78964	.65804	.01083	.00902	1.371	.1463	.08890
30.00	18.527	22.233	.89336	.74446	.89466	.74555	.01219	.01015	1.362	.1455	.09080
32.00	17.582	21.099	1.0041	.83672	1.0055	.83793	.01361	.01134	1.353	.1448	.09268
34.00	16.740	20.088	1.1205	.93376	1.1221	.93511	.01510	.01258	1.345	.1442	.09462
36.00	15.984	19.186	1.2427	1.0355	1.2444	1.0370	.01665	.01387	1.338	.1436	.09661
38.00	15.301	18.361	1.3704	1.1420	1.3724	1.1436	.01827	.01522	1.331	.1430	.09865
40.00	14.682	17.618	1.5037	1.2531	1.5058	1.2549	.01994	.01662	1.324	.1425	.10073
45.00	13.357	16.029	1.8607	1.5506	1.8634	1.5528	.02440	.02034	1.310	.1414	.10508
50.00	12.280	14.736	2.2510	1.8759	2.2542	1.8785	.02923	.02436	1.297	.1404	.11161
55.00	11.385	13.662	2.6737	2.2281	2.6774	2.2312	.03441	.02867	1.285	.1396	.11733
60.00	10.630	12.755	3.1279	2.6066	3.1323	2.6102	.03992	.03327	1.275	.1389	.12331
65.00	9.9830	11.988	3.6130	3.0108	3.6180	3.0150	.04577	.03814	1.265	.1383	.12951
70.00	9.4230	11.308	4.1281	3.4401	4.1338	3.4448	.05193	.04328	1.256	.1377	.13591
75.00	8.9331	10.720	4.6726	3.8938	4.6790	3.8991	.05840	.04867	1.248	.1372	.14247
80.00	8.5007	10.201	5.2458	4.3715	5.2530	4.3775	.06516	.05430	1.241	.1367	.14915
90.00	7.7719	9.3263	6.4761	5.3967	6.4849	5.4041	.07953	.06629	1.227	.1359	.16283

PROTON ENERGY MEV	ENERGY LOSS HEV/CH		PROTON RANGE GM/CM <sup>2</sup> CM		PATH LENGTH GM/CM <sup>2</sup> CM		PATH LENGTH STRAGGLING GM/CM <sup>2</sup> CM		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM <sup>2</sup>	HEV/CH	GM/CM <sup>2</sup>	CM	GM/CM <sup>2</sup>	CM	GM/CM <sup>2</sup>	PERCENT		
100.00	7.1810	8.6172	7.8143	6.5119	7.8249	6.5207	.09502	.07918	1.214	.17673
110.00	6.6919	8.0303	7.2562	7.0135	9.2687	7.7239	.11152	.09293	1.203	.19094
120.00	6.2803	7.5364	10.798	8.9982	10.812	9.0102	.13899	.10749	1.193	.20356
130.00	5.9290	7.1148	12.435	10.363	12.452	10.377	.14738	.12281	1.184	.22050
140.00	5.6256	6.7507	14.166	11.805	14.184	11.820	.16664	.13886	1.175	.23566
150.00	5.3609	6.4330	15.985	13.321	16.006	13.338	.18673	.15561	1.167	.25097
160.00	5.1279	6.1535	17.890	14.909	17.914	14.928	.20761	.17301	1.159	.26641
170.00	4.9212	5.9055	19.879	16.566	19.903	16.588	.22925	.19104	1.152	.28201
180.00	4.7367	5.6840	21.948	18.290	21.977	18.314	.25160	.20967	1.145	.29771
190.00	4.5709	5.4951	24.095	20.079	24.127	20.106	.27464	.22887	1.138	.31345
200.00	4.4212	5.3054	26.317	21.931	26.352	21.960	.29833	.24861	1.132	.32919
210.00	4.2853	5.1424	28.612	23.844	28.650	23.875	.32265	.26887	1.126	.34490
220.00	4.1612	4.9934	30.978	25.815	31.018	25.849	.34757	.28964	1.121	.36058
230.00	4.0477	4.8573	33.412	27.843	33.455	27.879	.37306	.31088	1.115	.37619
240.00	3.9435	4.7322	35.912	29.926	35.959	29.965	.39909	.33258	1.110	.39169
250.00	3.8475	4.6170	38.476	32.064	38.526	32.105	.42566	.35471	1.105	.40766
260.00	3.7587	4.5105	41.103	34.252	41.156	34.297	.45272	.37727	1.100	.42289
270.00	3.6764	4.4117	43.790	36.491	43.847	36.539	.48027	.40023	1.095	.43741
280.00	3.6000	4.3200	46.535	38.779	46.596	38.830	.50829	.42357	1.091	.45237
290.00	3.5287	4.2344	49.338	41.115	49.401	41.168	.53675	.44729	1.087	.46716
300.00	3.4621	4.1546	52.195	43.496	52.263	43.552	.56564	.47137	1.082	.48175
310.00	3.3999	4.0798	55.107	45.922	55.178	45.982	.59494	.49578	1.078	.49627
320.00	3.3415	4.0098	58.070	48.392	58.145	48.454	.62463	.52053	1.074	.51067
330.00	3.2866	3.9440	61.084	50.904	61.163	50.990	.65471	.54559	1.070	.52493
340.00	3.2350	3.8820	64.147	53.456	64.230	53.525	.68515	.57096	1.067	.53904
350.00	3.1864	3.8237	67.256	56.049	67.345	56.121	.71595	.59663	1.063	.55299
360.00	3.1405	3.7684	70.416	58.680	70.506	58.755	.74709	.62257	1.060	.56682
370.00	3.0971	3.7169	73.618	61.349	73.713	61.427	.77855	.64879	1.056	.58059
380.00	3.0560	3.6672	76.865	64.054	76.963	64.136	.81033	.67528	1.053	.59426
390.00	3.0171	3.6205	80.154	66.795	80.257	66.881	.84242	.70201	1.050	.60764
400.00	2.9801	3.5762	83.485	69.571	83.592	69.660	.87479	.72900	1.047	.62128
410.00	2.9450	3.5341	86.850	7						

# LUCITE

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.6944	118.85	99.045	99.171	1.2127	1.0160	.1263	.73922
510.00	2.6723	122.58	102.15	102.28	1.2477	1.0398	.1262	.74928
520.00	2.6510	126.33	105.27	105.41	1.2830	1.0691	.1261	.75905
530.00	2.6306	130.11	108.43	108.56	1.3184	1.0987	.1260	.76852
540.00	2.6111	133.92	111.60	111.74	1.3540	1.1284	.1259	.77770
550.00	2.5923	137.76	114.80	114.95	1.3898	1.1581	.1257	.78660
560.00	2.5742	141.63	118.02	118.17	1.4257	1.1881	.1256	.79521
570.00	2.5568	145.52	121.27	121.42	1.4610	1.2182	.1255	.80355
580.00	2.5400	149.44	124.53	124.69	1.4981	1.2484	.1253	.81161
590.00	2.5239	153.39	127.82	127.98	1.5346	1.2788	.1252	.81940
600.00	2.5083	157.36	131.13	131.29	1.5712	1.3093	.1251	.82693
620.00	2.4789	165.37	137.81	137.98	1.6448	1.3707	.1248	.84222
640.00	2.4515	173.47	144.56	144.74	1.7191	1.4326	.1246	.85453
660.00	2.4259	181.66	151.38	151.57	1.7938	1.4949	.1243	.86681
680.00	2.4020	189.94	158.28	158.48	1.8691	1.5576	.1241	.87840
700.00	2.3797	198.29	165.24	165.45	1.9449	1.6207	.1239	.88904
720.00	2.3587	206.73	172.27	172.49	2.0211	1.6842	.1236	.89887
740.00	2.3391	215.23	179.36	179.58	2.0977	1.7481	.1234	.90795
760.00	2.3206	223.81	186.51	186.74	2.1748	1.8123	.1231	.91631
780.00	2.3033	232.45	193.71	193.94	2.2523	1.8769	.1229	.92398
800.00	2.2869	241.15	200.96	201.21	2.3301	1.9418	.1226	.93100
820.00	2.2715	249.92	208.27	208.52	2.4083	2.0069	.1224	.93742
840.00	2.2570	258.74	215.62	215.88	2.4869	2.0724	.1222	.94329
860.00	2.2433	267.62	223.02	223.29	2.5653	2.1381	.1219	.94864
880.00	2.2303	276.56	230.46	230.74	2.6450	2.2041	.1217	.95352
900.00	2.2181	285.54	237.95	238.24	2.7245	2.2704	.1214	.95797
920.00	2.2065	294.58	245.48	245.78	2.8043	2.3369	.1212	.96202
940.00	2.1955	303.67	253.05	253.36	2.8843	2.4036	.1209	.96569
960.00	2.1851	312.80	260.67	260.98	2.9647	2.4706	.1206	.96904
1000.00	2.1658	331.28	276.07	276.40	3.1262	2.6051	.1199	.97485

THE ELECTRON DENSITY OF LUCITE IS 3.250E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.317 BEV, AND THE MINIMUM ENERGY LOSS IS 1.9877 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 67.09 ELECTRON VOLTS



ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECU-E	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL
C	6	1	74.8683	12.011	77.30
H	1	4	25.1317	1.0080	18.30

DENSITY = .71573 MG/CM3

362

## METHANE

FRCTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	99.101	70.929	.02834	.39590	.00054	.00033
5.50	91.782	65.691	.03358	.46921	.00063	.00041
6.00	85.550	61.230	.03923	.54811	.00073	.00152
6.50	80.175	57.383	.04521	.63168	.00083	.00309
7.00	75.489	54.329	.05170	.72235	.00093	.00467
7.50	71.361	51.075	.05852	.81758	.00105	.00625
8.00	67.698	48.454	.06571	.91811	.00116	.00782
8.50	64.424	46.110	.07328	1.0239	.00129	.00940
9.00	61.477	44.001	.08123	1.1350	.00142	.01098
9.50	58.810	42.092	.08955	1.2512	.00155	.01256
10.00	56.385	40.356	.09824	1.3725	.00169	.01415
11.00	52.134	37.314	.11670	1.6305	.00198	.01732
12.00	48.529	34.734	.13642	1.9084	.00229	.02051
13.00	45.429	32.515	.15790	2.2062	.00262	.02371
14.00	42.734	30.586	.18061	2.5235	.00297	.02692
15.00	40.368	28.892	.20470	2.8600	.00334	.03014
16.00	38.272	27.352	.23015	3.2156	.00372	.03337
17.00	36.402	25.054	.25695	3.5901	.00413	.03661
18.00	34.723	23.852	.28509	3.9832	.00455	.03987
19.00	33.206	23.766	.31454	4.3947	.00499	.04314
20.00	31.828	22.780	.34531	4.8246	.00545	.04641
22.00	29.419	21.056	.41025	5.7386	.00641	.05300
24.00	27.381	19.597	.48125	6.7239	.00744	.05963
26.00	25.633	18.347	.55615	7.7794	.00854	.06362
28.00	24.117	17.261	.63727	8.9039	.00969	.06486
30.00	22.788	16.310	.72263	10.096	.01091	.06616
32.00	21.613	15.469	.81279	11.356	.01219	.06750
34.00	20.566	14.720	.90768	12.682	.01353	.06888
36.00	19.627	14.042	1.0073	14.073	.01493	.07030
38.00	18.781	13.442	1.1115	15.529	.01639	.07176
40.00	18.013	12.892	1.2202	17.049	.01790	.07324
45.00	16.372	11.718	1.5118	21.122	.02192	.07707
50.00	15.039	10.764	1.8308	25.579	.02627	.08103
55.00	13.934	9.9726	2.1741	30.409	.03094	.08514
60.00	13.001	9.3051	2.5482	35.604	.03592	.08944
65.00	12.203	8.7342	2.9455	41.153	.04119	.09390
70.00	11.513	8.2401	3.3638	47.050	.04676	.09851
75.00	10.909	7.8081	3.8097	53.229	.05260	.10325
80.00	10.377	7.4270	4.2794	59.790	.05871	.10808
90.00	9.4802	6.7852	5.2879	73.881	.07171	.11799

METHANE

PRCTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PRCTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2		CH/CM2	PATH LENGTH STRAGGLING METER PERCENT		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
			GM/CM2	METER		GM/CM2	METER PERCENT		
100.00	8.7538	6.3856	6.3924	89.314	.08570	1.1774	1.341	.1068	.12810
110.00	8.1530	7.5691	7.5772	105.75	.11062	1.4059	1.328	.1063	.13847
120.00	7.6477	8.8351	8.8445	123.57	.13306	1.6267	1.316	.1059	.14922
130.00	7.2167	10.181	10.191	142.24	.15050	1.8591	1.306	.1055	.16027
140.00	6.8446	11.603	11.615	162.11	.16869	2.1027	1.296	.1051	.17157
150.00	6.5201	13.099	13.113	183.01	.18759	2.3568	1.286	.1048	.18304
160.00	6.2346	14.666	14.682	205.13	.20719	2.6210	1.278	.1045	.19471
170.00	5.9814	16.303	16.320	228.01	.22743	2.8948	1.270	.1042	.20659
180.00	5.7555	18.006	18.024	251.83	.24830	3.1777	1.262	.1040	.21863
190.00	5.5525	19.773	19.794	275.56	.26977	3.4693	1.254	.1038	.23080
200.00	5.3693	21.603	21.626	302.15	.29181	3.7692	1.247	.1035	.24306
210.00	5.2030	23.494	23.518	328.59	.31439	4.0771	1.241	.1033	.25540
220.00	5.0515	25.443	25.469	355.48	.33749	4.3926	1.234	.1031	.26781
230.00	4.9128	27.448	27.477	383.90	.36109	4.7153	1.228	.1029	.28026
240.00	4.7855	29.509	29.539	412.72	.38517	5.0451	1.222	.1027	.29272
250.00	4.6682	31.623	31.655	442.28	.40971	5.3816	1.217	.1026	.30517
260.00	4.5598	33.789	33.823	472.57	.43469	5.7244	1.211	.1024	.31760
270.00	4.4593	36.004	36.041	503.04	.46010	6.0734	1.206	.1022	.33002
280.00	4.3659	38.269	38.308	534.68	.48591	6.4284	1.201	.1021	.34239
290.00	4.2789	40.580	40.622	566.98	.51211	6.7890	1.196	.1019	.35470
300.00	4.1977	42.938	42.981	599.92	.53868	7.1551	1.191	.1018	.36695
310.00	4.1217	45.340	45.386	633.48	.56562	7.5264	1.187	.1016	.37941
320.00	4.0504	47.785	47.833	667.64	.59290	7.9027	1.182	.1015	.39191
330.00	3.9835	50.272	50.323	702.39	.62052	8.2839	1.178	.1013	.40444
340.00	3.9206	52.800	52.854	737.71	.64846	8.6698	1.174	.1012	.41699
350.00	3.8613	55.368	55.424	773.59	.67671	9.0602	1.170	.1011	.42953
360.00	3.8053	57.974	58.033	810.01	.70526	9.4549	1.166	.1009	.44214
370.00	3.7524	60.618	60.679	847.80	.73410	9.8538	1.162	.1008	.45484
380.00	3.7024	63.299	63.363	884.40	.76321	10.257	1.159	.1007	.46764
390.00	3.6549	66.015	66.081	923.27	.79260	10.663	1.155	.1005	.48050
400.00	3.6099	68.765	68.834	961.74	.82224	11.074	1.151	.1004	.49342
410.00	3.5672	71.549	71.621	999.67	.85214	11.488	1.148	.1003	.50628
420.00	3.5265	74.366	74.441	1039.0	.88227	11.906	1.145	.1002	.51899
430.00	3.4878	77.215	77.292	1079.9	.91264	12.327	1.141	.1001	.53156
440.00	3.4509	80.095	80.175	1119.1	.94324	12.751	1.138	.0999	.54395
450.00	3.4158	83.004	83.087	1159.7	.97405	13.179	1.135	.0998	.55618
460.00	3.3822	85.944	86.030	1200.8	1.0051	13.609	1.132	.0997	.56823
470.00	3.3501	88.912	89.001	1242.3	1.0363	14.043	1.129	.0996	.58010
480.00	3.3195	91.908	91.999	1284.1	1.0677	14.479	1.126	.0995	.59179
490.00	3.2901	94.931	95.025	1326.4		14.918	1.124	.0994	.60328

# METHANE

PROTON ENERGY MEV	ENERGY LOSS KEV/CH	PROTON RANGE GM/CH2	PROTON PATH LENGTH GM/CH2	PATH LENGTH STRAGGLING GM/CH2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	3.2620	97.981	98.078	1.0994	.0992	.61457
510.00	3.2351	101.06	101.16	1.1312	.0991	.62569
520.00	3.2092	104.16	104.26	1.1631	.0990	.63666
530.00	3.1844	107.28	107.39	1.1953	.0989	.64746
540.00	3.1606	110.43	110.54	1.2276	.0988	.65810
550.00	3.1378	113.60	113.72	1.2601	.0987	.66857
560.00	3.1158	116.80	116.91	1.2928	.0986	.67886
570.00	3.0946	120.02	120.13	1.3256	.0985	.68898
580.00	3.0742	123.26	123.38	1.3585	.0984	.69890
590.00	3.0546	126.52	126.64	1.3916	.0983	.70864
600.00	3.0357	129.80	129.92	1.4249	.0982	.71819
620.00	3.0000	136.42	136.55	1.4918	.0979	.73675
640.00	2.9667	143.12	143.26	1.5592	.0977	.75460
660.00	2.9356	149.89	150.03	1.6271	.0975	.77171
680.00	2.9066	156.73	156.88	1.6955	.0973	.78807
700.00	2.8795	163.64	163.79	1.7643	.0971	.80365
720.00	2.8541	170.61	170.77	1.8336	.0969	.81846
740.00	2.8302	177.64	177.81	1.9032	.0967	.83249
760.00	2.8078	184.73	184.90	1.9733	.0965	.84573
780.00	2.7868	191.87	192.05	2.0436	.0963	.85811
800.00	2.7670	199.07	199.26	2.1144	.0961	.86965
820.00	2.7483	206.31	206.51	2.1855	.0959	.88039
840.00	2.7307	213.61	213.81	2.2569	.0957	.89036
860.00	2.7141	220.95	221.16	2.3285	.0955	.89961
880.00	2.6984	228.33	228.55	2.4005	.0953	.90319
900.00	2.6836	235.76	235.99	2.4728	.0951	.91612
920.00	2.6696	243.23	243.46	2.5453	.0949	.92344
940.00	2.6563	250.75	250.98	2.6181	.0946	.93020
960.00	2.6437	258.30	258.54	2.6912	.0944	.93643
1000.00	2.6204	273.57	273.83	2.8380	.0938	.94745

THE ELECTRON DENSITY OF METHANE IS 3.755E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.378 BEV, AND THE MINIMUM ENERGY LOSS IS 2.4104 MEV/GM/CH2

THE EFFECTIVE IONIZATION POTENTIAL IS 43.44 ELECTRON VOLTS

# MUSCLE (HUMAN)

ELEMENT	ATOMIC NUMBER	ATOMS/MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL
H	1	10.119	10.1992	1.0080	59.30
C	6	1.0241	12.3007	12.011	77.30
N	7	.2486	3.4994	14.007	99.50
O	8	4.5562	72.8940	15.999	98.50
NA	11	.00348	.0800	22.990	150.1
MG	12	.00082	.0199	24.312	156.5
P	15	.00646	.2001	30.974	175.9
S	16	.01359	.4999	32.064	182.6
K	19	.00767	.2999	39.102	203.8
CA	20	.00017	.0068	40.080	211.3

DENSITY = 1.0000 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS GM/CM2 MEV/CM	PROTON RANGE HG/CM2 MM	PATH LENGTH HG/CM2 MM	PATH LENGTH STRAGGLING MM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	933.68	.11642	.11715	.00058	.6206	0.
.15	841.65	.17274	.17352	.00729	.4538	0.
.20	737.44	.23603	.23694	.00888	.3854	0.
.30	589.15	.38799	.38925	.01259	.3249	0.
.40	490.99	.57408	.57579	.01731	.2969	0.
.50	424.15	.79322	.79545	.02283	.2803	0.
.60	376.99	1.0431	1.0459	.02887	.2689	0.
.70	339.08	1.3220	1.3255	.03540	.2604	0.
.80	310.57	1.6295	1.6337	.04238	.2537	0.
.90	287.46	1.9632	1.9681	.04970	.2482	0.
1.00	264.31	2.3253	2.3309	.05753	.2434	0.
1.20	232.00	3.1329	3.1403	.07470	.2356	0.
1.40	207.51	4.0442	4.0535	.09341	.2297	0.
1.60	188.22	5.0559	5.0673	.11359	.2248	.00001
1.80	172.59	6.1647	6.1783	.13518	.2207	.00001
2.00	159.63	7.3682	7.3842	.15811	.2172	.00002
2.20	148.69	8.6644	8.6830	.18236	.2141	.00003
2.40	139.31	10.052	10.074	.20788	.2113	.00004
2.60	131.16	11.530	11.554	.23464	.2089	.00005
2.80	124.02	13.096	13.123	.26262	.2067	.00007
3.00	117.69	14.749	14.779	.29179	.2046	.00009
3.20	112.04	16.488	16.521	.32213	.2028	.00011
3.40	106.96	18.312	18.349	.35364	.2011	.00013
3.60	102.37	20.221	20.261	.38629	.1995	.00015
3.80	98.197	22.212	22.256	.42006	.1981	.00017
4.00	94.382	24.266	24.334	.45496	.1967	.00020
4.20	90.861	26.442	26.494	.49097	.1954	.00023
4.40	87.639	28.680	28.736	.52809	.1943	.00026
4.60	84.659	30.998	31.058	.56628	.1931	.00029
4.80	81.894	33.396	33.461	.60553	.1921	.00032

# MUSCLE

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE CH	PROTON PATH LENGTH CH/CH2	PATH LENGTH STRAGGLING GM/CH2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	79.322	73.322	.03594	.00065	1.797	.1911	.00036
5.50	73.606	73.606	.04249	.00075	1.768	.1888	.00045
6.00	68.724	68.724	.04953	.00086	1.743	.1866	.00077
6.50	64.536	64.536	.05704	.00098	1.720	.1850	.00124
7.00	60.820	60.820	.06503	.00111	1.700	.1833	.00254
7.50	57.528	57.528	.07348	.00124	1.682	.1815	.00441
8.00	54.645	54.645	.08240	.00137	1.666	.1805	.00629
8.50	52.062	52.062	.09178	.00152	1.651	.1793	.00817
9.00	49.733	49.733	.10161	.00166	1.638	.1782	.01005
9.50	47.622	47.622	.11189	.00182	1.625	.1771	.01193
10.00	45.698	45.698	.12261	.00198	1.613	.1761	.01382
11.00	42.321	42.321	.14537	.00231	1.592	.1744	.01760
12.00	39.449	39.449	.16986	.00267	1.574	.1728	.02139
13.00	36.975	36.975	.19606	.00305	1.558	.1714	.02521
14.00	34.819	34.819	.22394	.00345	1.543	.1702	.02903
15.00	32.923	32.923	.25349	.00388	1.529	.1691	.03286
16.00	31.242	31.242	.28468	.00432	1.517	.1681	.03671
17.00	29.740	29.740	.31750	.00478	1.506	.1671	.04057
18.00	28.389	28.389	.35193	.00526	1.496	.1663	.04444
19.00	27.167	27.167	.38794	.00577	1.487	.1655	.04833
20.00	26.057	26.057	.42554	.00629	1.478	.1648	.05223
22.00	24.112	24.112	.50540	.00739	1.462	.1634	.06006
24.00	22.465	22.465	.59139	.00856	1.448	.1623	.06793
26.00	21.050	21.050	.68342	.00981	1.435	.1612	.07271
28.00	19.820	19.820	.78139	.01112	1.423	.1603	.07431
30.00	18.742	18.742	.88520	.01251	1.413	.1595	.07597
32.00	17.787	17.787	.99479	.01396	1.403	.1587	.07749
34.00	16.936	16.936	1.1101	.01548	1.395	.1580	.07946
36.00	16.172	16.172	1.2309	.01706	1.386	.1574	.08128
38.00	15.483	15.483	1.3574	.01871	1.379	.1568	.08314
40.00	14.857	14.857	1.4893	.02042	1.371	.1563	.08505
45.00	13.518	13.518	1.8426	.02497	1.355	.1551	.08997
50.00	12.429	12.429	2.2287	.02989	1.341	.1540	.09505
55.00	11.525	11.525	2.6428	.03516	1.328	.1532	.10033
60.00	10.761	10.761	3.0961	.04078	1.317	.1524	.10585
65.00	10.107	10.107	3.5784	.04672	1.307	.1517	.11160
70.00	9.5411	9.5411	4.0791	.05299	1.297	.1511	.11754
75.00	9.0456	9.0456	4.6168	.05957	1.288	.1505	.12364
80.00	8.6083	8.6083	5.1906	.06645	1.280	.1500	.12988
90.00	7.8711	7.8711	6.4070	.08107	1.265	.1491	.14269

# MUSCLE

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING		PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GH/CM2	MEV/CM	GH/CM2	CM	GH/CM2	CM	GH/CM2	CM	PERCENT	PERCENT		
100.00	7.2733	7.2733	7.7186	7.7186	7.7301	7.7301	.09679	.09679	1.252	.1484	.15579	
110.00	6.7785	6.7785	9.1419	9.1419	9.1555	9.1555	.11354	.11354	1.240	.1478	.16921	
120.00	6.3620	6.3620	10.664	10.664	10.679	10.679	.13128	.13128	1.229	.1472	.18305	
130.00	6.0065	6.0065	12.280	12.280	12.298	12.298	.14994	.14994	1.219	.1467	.19719	
140.00	5.6994	5.6994	13.987	13.987	14.008	14.008	.16949	.16949	1.210	.1462	.21155	
150.00	5.4315	5.4315	15.783	15.783	15.806	15.806	.18988	.18988	1.201	.1458	.22606	
160.00	5.1956	5.1956	17.663	17.663	17.689	17.689	.21106	.21106	1.193	.1455	.24072	
170.00	4.9865	4.9865	19.626	19.626	19.654	19.654	.23300	.23300	1.185	.1451	.25553	
180.00	4.7997	4.7997	21.668	21.668	21.699	21.699	.25567	.25567	1.178	.1448	.27046	
190.00	4.6319	4.6319	23.786	23.786	23.821	23.821	.27903	.27903	1.171	.1445	.28543	
200.00	4.4803	4.4803	25.979	25.979	26.016	26.016	.30305	.30305	1.165	.1442	.30042	
210.00	4.3427	4.3427	28.243	28.243	28.284	28.284	.32770	.32770	1.159	.1440	.31541	
220.00	4.2173	4.2173	30.577	30.577	30.621	30.621	.35295	.35295	1.153	.1437	.33041	
230.00	4.1026	4.1026	32.978	32.978	33.025	33.025	.37878	.37878	1.147	.1435	.34537	
240.00	3.9972	3.9972	35.444	35.444	35.495	35.495	.40516	.40516	1.141	.1433	.36028	
250.00	3.9000	3.9000	37.974	37.974	38.026	38.026	.43207	.43207	1.136	.1431	.37509	
260.00	3.8098	3.8098	40.565	40.565	40.623	40.623	.45949	.45949	1.131	.1428	.38983	
270.00	3.7265	3.7265	43.216	43.216	43.277	43.277	.48740	.48740	1.126	.1427	.40452	
280.00	3.6490	3.6490	45.924	45.924	45.989	45.989	.51578	.51578	1.122	.1425	.41912	
290.00	3.5769	3.5769	48.688	48.688	48.757	48.757	.54460	.54460	1.117	.1423	.43362	
300.00	3.5095	3.5095	51.507	51.507	51.581	51.581	.57385	.57385	1.113	.1421	.44800	
310.00	3.4464	3.4464	54.379	54.379	54.456	54.456	.60352	.60352	1.108	.1419	.46237	
320.00	3.3873	3.3873	57.302	57.302	57.383	57.383	.63359	.63359	1.104	.1418	.47664	
330.00	3.3317	3.3317	60.275	60.275	60.360	60.360	.66404	.66404	1.100	.1416	.49080	
340.00	3.2795	3.2795	63.296	63.296	63.385	63.385	.69486	.69486	1.096	.1414	.50482	
350.00	3.2302	3.2302	66.364	66.364	66.458	66.458	.72604	.72604	1.092	.1413	.51870	
360.00	3.1837	3.1837	69.478	69.478	69.576	69.576	.75756	.75756	1.089	.1411	.53248	
370.00	3.1398	3.1398	72.636	72.636	72.739	72.739	.78940	.78940	1.085	.1410	.54620	
380.00	3.0981	3.0981	75.838	75.838	75.945	75.945	.82157	.82157	1.082	.1408	.55983	
390.00	3.0587	3.0587	79.084	79.084	79.195	79.195	.85404	.85404	1.078	.1407	.57336	
400.00	3.0213	3.0213	82.369	82.369	82.485	82.485	.88681	.88681	1.075	.1405	.58677	
410.00	2.9857	2.9857	85.694	85.694	85.815	85.815	.91986	.91986	1.072	.1404	.59998	
420.00	2.9519	2.9519	89.058	89.058	89.183	89.183	.95319	.95319	1.069	.1402	.61292	
430.00	2.9197	2.9197	92.460	92.460	92.589	92.589	.98678	.98678	1.066	.1401	.62558	
440.00	2.8891	2.8891	95.898	95.898	96.033	96.033	1.0206	1.0206	1.063	.1400	.63797	
450.00	2.8598	2.8598	99.372	99.372	99.512	99.512	1.0547	1.0547	1.060	.1398	.65007	
460.00	2.8319	2.8319	102.88	102.88	103.03	103.03	1.0891	1.0891	1.057	.1397	.66188	
470.00	2.8052	2.8052	106.43	106.43	106.57	106.57	1.1236	1.1236	1.054	.1395	.67341	
480.00	2.7796	2.7796	110.00	110.00	110.16	110.16	1.1584	1.1584	1.052	.1394	.68465	
490.00	2.7552	2.7552	113.61	113.61	113.77	113.77	1.1935	1.1935	1.049	.1393	.69560	

# MUSCLE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CH	GM/CM2	PERCENT		
500.00	2.7318	117.25	117.25	117.41	117.41	1.2287	1.046	.1391	.70627
510.00	2.7093	120.92	120.92	121.09	121.09	1.2641	1.044	.1390	.71666
520.00	2.6878	124.62	124.62	124.80	124.80	1.2997	1.041	.1389	.72678
530.00	2.6672	128.35	128.35	128.53	128.53	1.3356	1.039	.1387	.73664
540.00	2.6473	132.11	132.11	132.29	132.29	1.3716	1.037	.1386	.74624
550.00	2.6283	135.90	135.90	136.08	136.08	1.4077	1.034	.1385	.75557
560.00	2.6099	139.71	139.71	139.90	139.90	1.4441	1.032	.1383	.76464
570.00	2.5923	143.55	143.55	143.75	143.75	1.4806	1.030	.1382	.77345
580.00	2.5753	147.41	147.41	147.62	147.62	1.5173	1.028	.1381	.78200
590.00	2.5589	151.30	151.30	151.51	151.51	1.5542	1.026	.1379	.79031
600.00	2.5432	155.22	155.22	155.43	155.43	1.5912	1.024	.1378	.79836
620.00	2.5133	163.12	163.12	163.34	163.34	1.6656	1.020	.1375	.81374
640.00	2.4855	171.11	171.11	171.35	171.35	1.7407	1.016	.1373	.82819
660.00	2.4596	179.19	179.19	179.44	179.44	1.8163	1.012	.1370	.84175
680.00	2.4354	187.35	187.35	187.61	187.61	1.8923	1.009	.1368	.85442
700.00	2.4127	195.59	195.59	195.86	195.86	1.9689	1.005	.1365	.86627
720.00	2.3914	203.91	203.91	204.19	204.19	2.0459	1.002	.1362	.87730
740.00	2.3715	212.30	212.30	212.59	212.59	2.1234	.9988	.1360	.88757
760.00	2.3528	220.75	220.75	221.05	221.05	2.2013	.9958	.1357	.89711
780.00	2.3352	229.28	229.28	229.59	229.59	2.2796	.9929	.1355	.90591
800.00	2.3186	237.86	237.86	238.18	238.18	2.3582	.9901	.1352	.91403
820.00	2.3030	246.51	246.51	246.84	246.84	2.4372	.9874	.1350	.92151
840.00	2.2882	255.21	255.21	255.55	255.55	2.5166	.9848	.1347	.92840
860.00	2.2743	263.97	263.97	264.32	264.32	2.5963	.9823	.1344	.93472
880.00	2.2611	272.78	272.78	273.14	273.14	2.6763	.9798	.1342	.94053
900.00	2.2487	281.64	281.64	282.02	282.02	2.7566	.9775	.1339	.94586
920.00	2.2369	290.55	290.55	290.94	290.94	2.8373	.9752	.1337	.95074
940.00	2.2258	299.51	299.51	299.91	299.91	2.9181	.9730	.1334	.95521
960.00	2.2152	308.53	308.53	308.94	308.94	2.9993	.9708	.1331	.95930
1000.00	2.1956	326.75	326.75	327.18	327.18	3.1624	.9666	.1323	.96649

THE ELECTRON DENSITY OF MUSCLE IS 3.314E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.309 BEV, AND THE MINIMUM ENERGY LOSS IS 2.0131 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 70.80 ELECTRON VOLTS



# NYLON

PROTON ENERGY MEV	ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL	PATH LENGTH STRAGGLING MM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	H	1	13	9.9393	1.0080	18.30	.00511	.5691	0.
.15	N	7	1.	10.6778	14.007	99.50	.00639	.4205	0.
.20	C	6	6.	54.9391	12.011	77.30	.00779	.3548	0.
.30	O	8	2.	24.3938	15.999	98.50	.01126	.2950	0.
.40							.00010	.2672	0.
.50							.00014	.2509	0.
.60							.00018	.2400	0.
.70							.00023	.2321	0.
.80							.00029	.2259	0.
.90							.00035	.2208	0.
							.00041		
							.00047		
1.00							.05355	.2166	0.
1.20							.06991	.2098	0.
1.40							.08764	.2046	0.
1.60							.10672	.2003	.00001
1.80							.12710	.1967	.00001
2.00							.14875	.1936	.00002
2.20							.17164	.1909	.00003
2.40							.19574	.1884	.00005
2.60							.22104	.1863	.00007
2.80							.24751	.1843	.00009
							.00219		
							.00243		
3.00							.27515	.1825	.00011
3.20							.30393	.1809	.00013
3.40							.33383	.1794	.00016
3.60							.36485	.1780	.00016
3.80							.39698	.1767	.00021
4.00							.43019	.1754	.00025
4.20							.46457	.1743	.00028
4.40							.50004	.1732	.00031
4.60							.53655	.1722	.00035
4.80							.57409	.1713	.00039
							.00269		
							.00295		
							.00323		
							.00351		
							.00381		
							.00411		
							.00443		
							.00475		
							.00506		
							.12800		
							.14312		
							.15898		
							.17558		
							.19290		
							.21095		
							.22972		
							.24922		
							.26940		
							.29030		
							.12776		
							.14286		
							.15669		
							.17527		
							.19256		
							.21037		
							.22832		
							.24679		
							.26593		
							.28481		
							.14.437		
							.16.143		
							.17.932		
							.19.805		
							.21.759		
							.23.795		
							.25.914		
							.28.113		
							.30.389		
							.32.748		
							.142.96		
							.135.64		
							.129.11		
							.123.23		
							.117.91		
							.113.08		
							.108.67		
							.104.52		
							.100.07		
							.96.165		
							.92.491		
							.89.201		
							.86.158		
							.83.334		

DENSITY = 1.1300 GM/CM3

NYLON

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	80.707	91.198	.03510	.03114	.00661	.00054	.1704
5.50	74.869	84.601	.04161	.03682	.00071	.00063	.00043
6.00	69.877	78.961	.04852	.04301	.00082	.00073	.00055
6.50	65.572	74.096	.05590	.04947	.00093	.00083	.00158
7.00	61.810	69.845	.06374	.05641	.00105	.00093	.00318
7.50	58.478	66.081	.07205	.06376	.00118	.00104	.00513
8.00	55.531	62.750	.08081	.07132	.00131	.00116	.00726
8.50	52.892	59.768	.09003	.07967	.00145	.00128	.00939
9.00	50.514	57.081	.09969	.08822	.00159	.00141	.01132
9.50	48.359	54.645	.10980	.09716	.00174	.00154	.01365
10.00	46.396	52.428	.12034	.10649	.00189	.00168	.01578
11.00	42.952	48.535	.14273	.12631	.00222	.00196	.01792
12.00	40.024	45.228	.16683	.14786	.00236	.00227	.02218
13.00	37.504	42.379	.19261	.17045	.00293	.00259	.02646
14.00	35.309	39.899	.22007	.19475	.00332	.00294	.03074
15.00	33.379	37.718	.24917	.22030	.00373	.00330	.03503
16.00	31.668	35.785	.27989	.24789	.00416	.00368	.03933
17.00	30.240	34.058	.31223	.27631	.00460	.00407	.04334
18.00	28.766	32.506	.34615	.30633	.00507	.00449	.04796
19.00	27.524	31.102	.38165	.33774	.00556	.00492	.05229
20.00	26.395	29.827	.41871	.37034	.00606	.00537	.05662
22.00	24.420	27.594	.49744	.44021	.00713	.00631	.06097
24.00	22.746	25.703	.58225	.51526	.00827	.00732	.06969
26.00	21.309	24.079	.67302	.59559	.00948	.00839	.07844
28.00	20.061	22.669	.76967	.68113	.01076	.00952	.08371
30.00	18.966	21.432	.87211	.77178	.01211	.01072	.08539
32.00	17.998	20.338	.98025	.86749	.01352	.01197	.08714
34.00	17.135	19.362	1.0940	.96817	.01500	.01328	.08895
36.00	16.360	18.487	1.2134	1.0738	.01654	.01464	.09082
38.00	15.661	17.696	1.3382	1.1842	.01815	.01606	.09274
40.00	15.026	16.979	1.4684	1.2995	.01982	.01754	.09470
45.00	13.669	15.446	1.8173	1.6082	.02425	.02146	.09670
50.00	12.565	14.199	2.1987	1.9458	.02904	.02570	.10166
55.00	11.649	13.163	2.6118	2.3113	.03418	.03025	.10719
60.00	10.875	12.289	3.0538	2.7042	.03966	.03510	.11270
65.00	10.213	11.541	3.5299	3.1238	.04547	.04024	.11847
70.00	9.6400	10.893	4.0334	3.5694	.05159	.04566	.12445
75.00	9.1384	10.326	4.5657	4.0404	.05802	.05134	.13061
80.00	8.6957	9.8261	5.1260	4.5363	.06474	.05729	.13693
90.00	7.9496	8.9830	6.3288	5.6007	.07902	.06993	.14338
							.15656

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	KEV/ GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
100.00	7.3447	8.2995	7.6372	6.7586	7.6473	6.7675	.09439	.08353	1.234	.16997
110.00	6.6441	7.7339	9.0470	8.0062	9.0589	8.0168	.11078	.09803	1.223	.18366
120.00	6.4228	7.2578	10.554	9.3402	10.568	9.3525	.12813	.11339	1.212	.19777
130.00	6.0633	6.8515	12.156	10.757	12.172	10.771	.14639	.12955	1.203	.21219
140.00	5.7528	6.5006	13.848	12.255	13.866	12.271	.16553	.14648	1.194	.22683
150.00	5.4819	6.1945	15.627	13.829	15.647	13.847	.18548	.16414	1.185	.24161
160.00	5.2434	5.9251	17.490	15.478	17.513	15.498	.20622	.18250	1.178	.25654
170.00	5.0320	5.6861	19.435	17.200	19.461	17.222	.22771	.20151	1.170	.27164
180.00	4.8432	5.4728	21.459	18.990	21.487	19.015	.24991	.22116	1.163	.28685
190.00	4.6735	5.2811	23.559	20.849	23.509	20.875	.27279	.24141	1.156	.30213
200.00	4.5203	5.1080	25.732	22.772	25.765	22.801	.29632	.26223	1.150	.31742
210.00	4.3813	4.9509	27.977	24.758	28.013	24.790	.32048	.28361	1.144	.33271
220.00	4.2546	4.8077	30.291	26.806	30.330	26.840	.34522	.30551	1.138	.34801
230.00	4.1382	4.6762	32.671	28.913	32.713	28.950	.37054	.32791	1.133	.36328
240.00	4.0316	4.5557	35.117	31.077	35.162	31.117	.39640	.35079	1.127	.37848
250.00	3.9334	4.4447	37.625	33.297	37.673	33.339	.42278	.37414	1.122	.39359
260.00	3.8425	4.3421	40.194	35.570	40.245	35.615	.44966	.39793	1.117	.40859
270.00	3.7583	4.2469	42.823	37.897	42.878	37.945	.47702	.42215	1.113	.42348
280.00	3.6801	4.1585	45.509	40.274	45.567	40.325	.50485	.44677	1.108	.43823
290.00	3.6072	4.0761	48.251	42.700	48.312	42.754	.53311	.47178	1.103	.45283
300.00	3.5391	3.9991	51.046	45.174	51.111	45.131	.56180	.49717	1.099	.46725
310.00	3.4753	3.9271	53.894	47.694	53.962	47.754	.59090	.52292	1.095	.48162
320.00	3.4156	3.8596	56.793	50.259	56.865	50.323	.62039	.54902	1.091	.49588
330.00	3.3595	3.7962	59.743	52.870	59.818	52.936	.65026	.57546	1.087	.51001
340.00	3.3066	3.7365	62.739	55.522	62.818	55.591	.68050	.60221	1.083	.52400
350.00	3.2569	3.6803	65.783	58.215	65.866	58.288	.71108	.62928	1.080	.53782
360.00	3.2099	3.6272	68.872	60.949	68.959	61.025	.74201	.65664	1.076	.55155
370.00	3.1655	3.5770	72.006	63.722	72.096	63.802	.77325	.68430	1.073	.56524
380.00	3.1234	3.5295	75.182	66.533	75.276	66.616	.80482	.71223	1.069	.57886
390.00	3.0836	3.4845	78.401	69.381	78.499	69.468	.83618	.74043	1.066	.59240
400.00	3.0458	3.4417	81.660	72.265	81.762	72.356	.86884	.76888	1.063	.60583
410.00	3.0099	3.4011	84.959	75.185	85.065	75.278	.90127	.79759	1.060	.6190

# NYLON

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.7533	3.1112	116.27	102.89	116.41	103.02	1.234	.72479
510.00	2.7306	3.0856	119.91	106.12	120.06	106.25	1.233	.73504
520.00	2.7089	3.0610	123.59	109.37	123.74	109.50	1.231	.74501
530.00	2.6880	3.0374	127.29	112.64	127.44	112.78	1.230	.75470
540.00	2.6679	3.0148	131.02	115.94	131.18	116.09	1.229	.76412
550.00	2.6487	2.9930	134.77	119.27	134.94	119.42	1.228	.77325
560.00	2.6302	2.9721	138.56	122.62	138.73	122.77	1.226	.78212
570.00	2.6123	2.9519	142.37	125.99	142.54	126.14	1.225	.79072
580.00	2.5952	2.9325	146.21	129.39	146.38	129.54	1.224	.79905
590.00	2.5786	2.9139	150.07	132.80	150.25	132.96	1.223	.80712
600.00	2.5627	2.8959	153.95	136.24	154.14	136.41	1.222	.81492
620.00	2.5325	2.8618	161.79	143.18	161.99	143.36	1.219	.82980
640.00	2.5045	2.8300	169.73	150.20	169.93	150.38	1.217	.84371
660.00	2.4783	2.8004	177.75	157.30	177.96	157.49	1.214	.85670
680.00	2.4538	2.7728	185.85	164.47	186.07	164.67	1.212	.86878
700.00	2.4309	2.7469	194.03	171.71	194.26	171.91	1.209	.88004
720.00	2.4094	2.7226	202.28	179.01	202.53	179.23	1.207	.89047
740.00	2.3892	2.6998	210.61	186.38	210.86	186.60	1.205	.90013
760.00	2.3703	2.6784	219.00	193.81	219.27	194.04	1.202	.90905
780.00	2.3525	2.6583	227.47	201.30	227.74	201.54	1.200	.91726
800.00	2.3357	2.6394	235.99	208.84	236.27	209.09	1.198	.92479
820.00	2.3199	2.6215	244.57	216.44	244.86	216.69	1.195	.93170
840.00	2.3050	2.6047	253.21	224.08	253.51	224.35	1.193	.93802
860.00	2.2910	2.5888	261.91	231.78	262.22	232.05	1.191	.94380
880.00	2.2777	2.5738	270.66	239.52	270.98	239.80	1.188	.94909
900.00	2.2651	2.5595	279.45	247.30	279.79	247.60	1.186	.95391
920.00	2.2532	2.5461	288.30	255.14	288.65	255.44	1.183	.95830
940.00	2.2419	2.5333	297.20	263.01	297.55	263.32	1.181	.96230
960.00	2.2312	2.5213	306.15	270.93	306.51	271.25	1.178	.96595
1000.00	2.2114	2.4989	324.25	286.94	324.63	287.28	1.171	.97229

THE ELECTRON DENSITY OF NYLON IS 3.307E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.323 BEV, AND THE MINIMUM ENERGY LOSS IS 2.0265 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 64.45 ELECTRON VOLTS

**POLYETHYLENE**

ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
						MG/CM2	MM	MG/CM2	MM	MG/CM2	MM		
C	6	1	85.6262	12.011	77.1	.10282	.00112	.10491	.00005	4.779	.4758	0.	
H	1	2	14.3718	1.0080	12	.14786	.00161	.00589	.00006	3.982	.3548	0.	
						.20060	.00217	.00715	.00008	3.563	.3013	0.	
						.32913	.00350	.01037	.00011	3.142	.2508	0.	
						.48986	.00532	.01440	.00016	2.933	.2280	0.	
						.68094	.00740	.02190	.00021	2.799	.2149	0.	
						.90110	.00979	.02432	.00026	2.693	.2061	0.	
						1.1481	.01248	.02998	.00033	2.606	.1998	0.	
						1.4222	.01545	.03611	.00039	2.534	.1949	0.	
						1.7216	.01871	.04265	.00046	2.472	.1909	0.	
						2.0470	.02225	.04961	.00054	2.419	.1876	0.	
						2.7733	.03014	.06481	.00070	2.333	.1822	0.	
						3.5936	.03906	.08128	.00088	2.258	.1780	0.	
						4.5050	.04897	.09900	.00108	2.194	.1746	.00001	
						5.5047	.05883	.11794	.00128	2.139	.1717	.00001	
						6.5904	.07163	.13808	.00150	2.092	.1691	.00002	
						7.7607	.08436	.15939	.00173	2.050	.1669	.00003	
						9.0150	.09799	.18187	.00198	2.014	.1649	.00005	
						10.351	.11252	.20348	.00223	1.982	.1631	.00007	
						11.769	.12792	.23023	.00250	1.953	.1615	.00009	
						13.266	.14420	.25608	.00278	1.927	.1600	.00011	
						14.843	.16134	.28304	.00308	1.904	.1586	.00013	
						16.498	.17933	.31108	.00338	1.883	.1573	.00016	
						18.232	.19817	.34019	.00370	1.863	.1562	.00018	
						20.041	.21784	.37037	.00403	1.843	.1551	.00021	
						21.927	.23834	.40159	.00437	1.829	.1541	.00024	
						23.891	.25969	.43400	.00472	1.814	.1531	.00028	
						25.932	.28187	.46746	.00508	1.800	.1522	.00031	
						28.043	.30482	.50192	.00546	1.787	.1514	.00035	
						30.279	.32862	.53736	.00584	1.773	.1506	.00039	

## POLYETHYLENE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GH/CM2	PROTON PATH LENGTH GH/CM2	PATH LENGTH STRAGGLING GH/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	86.925	0.3249	0.3537	0.0097	1.763	.00043
5.50	80.581	0.3847	0.4187	0.0067	1.737	.00054
6.00	75.170	0.4489	0.4886	0.0077	1.714	.00196
6.50	70.497	0.5175	0.5633	0.0088	1.694	.00463
7.00	66.417	0.5905	0.6428	0.0099	1.675	.00607
7.50	62.822	0.6678	0.7269	0.0111	1.659	.00812
8.00	59.628	0.7494	0.8158	0.0123	1.644	.01016
8.50	56.770	0.8353	0.9092	0.0136	1.631	.01221
9.00	54.196	0.9253	1.0072	0.0150	1.618	.01425
9.50	51.865	1.0196	1.1098	0.0164	1.607	.01630
10.00	49.744	1.1173	1.2168	0.0179	1.596	.01834
11.00	46.024	1.3243	1.4422	0.0210	1.577	.02244
12.00	42.865	1.5516	1.6890	0.0243	1.561	.02654
13.00	40.147	1.7927	1.9512	0.0277	1.546	.03065
14.00	37.782	2.0493	2.2305	0.0314	1.533	.03477
15.00	35.704	2.3243	2.5265	0.0353	1.520	.03890
16.00	33.863	2.6086	2.8392	0.0394	1.509	.04304
17.00	32.219	2.9111	3.1684	0.0437	1.499	.04719
18.00	30.742	3.2286	3.5139	0.0482	1.490	.05135
19.00	29.407	3.5608	3.8755	0.0528	1.481	.05552
20.00	28.195	3.9073	4.2531	0.0576	1.473	.05969
22.00	26.073	4.6452	5.0556	0.0737	1.459	.06807
24.00	24.277	5.4397	5.9203	0.0856	1.446	.07648
26.00	22.736	6.2905	6.8462	0.0983	1.434	.08153
28.00	21.398	7.1965	7.8323	0.1026	1.423	.08310
30.00	20.225	8.1573	8.8778	0.1134	1.413	.08473
32.00	19.187	9.1717	9.9818	0.1290	1.405	.08643
34.00	18.263	1.0239	1.1143	0.1431	1.396	.08817
36.00	17.433	1.1359	1.2362	0.1579	1.389	.08996
38.00	16.685	1.2531	1.3637	0.1733	1.381	.09179
40.00	16.006	1.3753	1.4968	0.1893	1.375	.09367
45.00	14.555	1.7030	1.8533	0.2318	1.359	.09849
50.00	13.275	2.0613	2.2406	0.2777	1.346	.10346
55.00	12.396	2.4495	2.6657	0.3271	1.334	.10860
60.00	11.570	2.8668	3.1199	0.3797	1.323	.11398
65.00	10.863	3.3126	3.6050	0.4354	1.313	.11956
70.00	10.251	3.7861	4.1203	0.4942	1.304	.12531
75.00	9.7155	4.2868	4.6651	0.5559	1.295	.13121
80.00	9.232	4.8140	5.2389	0.6205	1.287	.13722
90.00	8.4475	5.9459	6.4706	0.7578	1.273	.14951

## POLYETHYLENE

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH GM/CM2 CM		PATH LENGTH STRAGGLING GM/CM2 CM		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
100.00	7.8026	7.1776	7.8017	7.1860	7.8108	.09056	.09843	1.260	.16199
110.00	7.2691	8.5050	9.2446	8.5149	9.2554	.10632	.11556	1.249	.17476
120.00	6.8202	9.9246	10.788	9.9362	10.800	.12301	.13370	1.238	.18794
130.00	6.4372	11.433	12.427	11.446	12.442	.14058	.15280	1.228	.20145
140.00	6.1065	13.027	14.180	13.042	14.176	.15899	.17281	1.219	.21519
150.00	5.8180	14.704	15.982	14.721	16.001	.17819	.19369	1.211	.22910
160.00	5.5642	16.460	17.891	16.479	17.912	.19816	.21539	1.203	.24318
170.00	5.3391	18.293	19.884	18.314	19.907	.21805	.23788	1.195	.25745
180.00	5.1381	20.201	21.957	20.224	21.982	.24023	.26111	1.188	.27186
190.00	4.9576	22.180	24.109	22.206	24.137	.26226	.28507	1.181	.28636
200.00	4.7946	24.230	26.337	24.257	26.367	.28492	.30970	1.175	.30090
210.00	4.6466	26.346	28.637	26.376	28.670	.30819	.33499	1.168	.31546
220.00	4.5118	28.528	31.009	28.561	31.044	.33203	.36090	1.163	.33004
230.00	4.3884	30.774	33.450	30.809	33.488	.35642	.38741	1.157	.34458
240.00	4.2751	33.080	35.957	33.118	35.997	.38133	.41449	1.151	.35908
250.00	4.1707	35.446	38.528	35.486	38.572	.40675	.44212	1.146	.37349
260.00	4.0742	37.870	41.163	37.912	41.209	.43266	.47026	1.141	.38780
270.00	3.9847	40.349	43.858	40.395	43.907	.45903	.49894	1.136	.40202
280.00	3.9009	42.884	46.613	42.932	46.665	.48584	.52609	1.132	.41612
290.00	3.8234	45.470	49.424	45.521	49.479	.51309	.55771	1.127	.43008
300.00	3.7510	48.108	52.291	48.162	52.350	.54075	.58777	1.123	.44368
310.00	3.6832	50.795	55.212	50.852	55.274	.56880	.61820	1.119	.45771
320.00	3.6196	53.532	58.187	53.592	58.252	.59723	.64917	1.114	.47149
330.00	3.5599	56.315	61.212	56.378	61.280	.62603	.68047	1.110	.48521
340.00	3.5037	59.144	64.287	59.210	64.358	.65519	.71216	1.107	.49884
350.00	3.4508	62.017	67.409	62.086	67.484	.68468	.74422	1.103	.51237
360.00	3.4008	64.933	70.579	65.005	70.657	.71450	.77663	1.099	.52586
370.00	3.3536	67.890	73.704	67.966	73.876	.74463	.80938	1.096	.53937
380.00	3.3088	70.889	77.053	70.968	77.139	.77507	.84247	1.092	.55287
390.00	3.2664	73.927	80.356	74.009	80.445	.80581	.87588	1.089	.56635
400.00	3.2262	77.004	83.701	77.090	83.793	.83682	.90959	1.086	.57977
410.00	3.1880	80.119	87.066	80.208	87.182	.86811	.94360	1.082	.59304
420.00	3.1516	83.270	90.511	83.362	90.611	.89967	.97790	1.079	.60605
430.00	3.1170	86.460	93.978	86.555	94.082	.93146	1.0125	1.076	.61880
440.00	3.0840	89.682	97.480	89.781	97.588	.96353	1.0473	1.073	.63129
450.00	3.0526	92.938	101.02	93.040	101.13	.99583	1.0824	1.070	.64351
460.00	3.0225	96.226	104.59	96.332	104.71	1.0284	1.1178	1.068	.65545
470.00	2.9938	99.547	108.20	99.656	108.32	1.0611	1.1534	1.065	.66712
480.00	2.9663	102.90	111.85	103.01	111.97	1.0941	1.1892	1.062	.67851
490.00	2.9400	106.28	115.52	106.40	115.65	1.1272	1.2253	1.059	.68962

POLYETHYLENE

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE GH/CH2	PROTON PATH LENGTH GH/CH2	PATH LENGTH STRAGGLING GH/CH2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.9148	2.6817	109.81	1.1606	1.092	.70045
510.00	2.8907	2.6594	113.26	1.1942	1.091	.71102
520.00	2.8675	2.6381	116.73	1.2280	1.090	.72133
530.00	2.8453	2.6177	120.23	1.2619	1.089	.73139
540.00	2.8239	2.5980	123.76	1.2960	1.088	.74120
550.00	2.8034	2.5791	127.32	1.3303	1.086	.75075
560.00	2.7837	2.5610	130.90	1.3648	1.085	.76004
570.00	2.7647	2.5435	134.50	1.3994	1.084	.76908
580.00	2.7464	2.5267	138.13	1.4342	1.083	.77787
590.00	2.7288	2.5105	141.78	1.4692	1.082	.78641
600.00	2.7118	2.4948	145.46	1.5043	1.081	.79470
620.00	2.6796	2.4652	152.88	1.5749	1.079	.81057
640.00	2.6497	2.4377	160.39	1.6460	1.076	.82551
660.00	2.6217	2.4120	167.97	1.7177	1.074	.83954
680.00	2.5955	2.3879	175.64	1.7899	1.072	.85270
700.00	2.5711	2.3654	183.38	1.8626	1.070	.86500
720.00	2.5481	2.3443	191.20	1.9357	1.068	.87647
740.00	2.5266	2.3243	199.08	2.0092	1.066	.88715
760.00	2.5064	2.3059	207.03	2.0832	1.063	.89706
780.00	2.4874	2.2884	215.04	2.1575	1.061	.90621
800.00	2.4694	2.2719	223.11	2.2322	1.059	.91462
820.00	2.4525	2.2563	231.24	2.3072	1.057	.92336
840.00	2.4366	2.2416	239.42	2.3826	1.055	.93197
860.00	2.4215	2.2278	247.66	2.4583	1.053	.93998
880.00	2.4072	2.2146	255.94	2.5343	1.051	.94740
900.00	2.3937	2.2022	264.28	2.6106	1.048	.95339
920.00	2.3809	2.1905	272.66	2.6872	1.046	.95694
940.00	2.3688	2.1793	281.09	2.7640	1.044	.96109
960.00	2.3574	2.1688	289.57	2.8412	1.041	.96431
1000.00	2.3361	2.1492	306.71	2.9962	1.035	.96831

THE ELECTRON DENSITY OF POLYETHYLENE IS 3.436E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.350 BEV, AND THE MINIMUM ENERGY LOSS IS 2.1343 MEV/GH/CH2

THE EFFECTIVE IONIZATION POTENTIAL IS 55.92 ELECTRON VOLTS



## POLYSTYRENE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	ELEMENT C H	ATOMIC NUMBER 6 1	ATOMS/ MOLECULE 1 1	PERCENT BY WEIGHT 92.2578 7.7422	ATOMIC WEIGHT 12.011 1.0080	ADJUSTED IONIZATION POTENTIAL 77.30 18.30	PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
								MG/CM2	MM		
.10	1028.7							.00510	.00005	.5622	0.
.15	882.01							.00611	.00006	.4208	0.
.20	766.95							.00741	.00007	.3549	0.
.30	604.78							.01075	.00010	.2928	0.
.40	500.91							.01493	.00014	.2631	0.
.50	430.52							.01979	.00019	.2456	0.
.60	380.12							.02519	.00024	.2338	0.
.70	342.19							.03105	.00029	.2254	0.
.80	310.5							.03740	.00035	.2168	0.
.90	287.10							.04417	.00042	.2135	0.
1.00	264.02							.05137	.00048	.2091	0.
1.20	232.10							.06710	.00063	.2020	0.
1.40	207.88							.08414	.00079	.1967	.00001
1.60	188.77							.10247	.00097	.1923	.00001
1.80	173.22							.12206	.00115	.1886	.00002
2.00	160.29							.14288	.00135	.1855	.00003
2.20	149.35							.16492	.00156	.1827	.00004
2.40	139.94							.18815	.00178	.1802	.00006
2.60	131.76							.21257	.00201	.1780	.00008
2.80	124.57							.23815	.00225	.1761	.00010
3.00	118.20							.26487	.00250	.1743	.00013
3.20	112.50							.29273	.00276	.1725	.00015
3.40	107.39							.32171	.00303	.1711	.00018
3.60	102.75							.35179	.00332	.1697	.00022
3.80	98.541							.38297	.00361	.1684	.00025
4.00	94.691							.41524	.00392	.1672	.00029
4.20	91.010							.44873	.00423	.1660	.00033
4.40	87.776							.48330	.00456	.1650	.00037
4.60	84.784							.51890	.00490	.1640	.00041
4.80	82.008							.55552	.00524	.1630	.00046

DENSITY = 1.0600 GM/CM3

## POLYSTYRENE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CH2	PROTON RANGE GM/CH2	CH	PROTON PATH LENGTH GM/CH2	CH	PATH LENGTH STRAGGLING GM/CH2	CH	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	79.423	84.189	.03374	.03583	.03380	.00059	.00056	1.656	.1621	.00051
5.50	73.679	78.100	.03991	.04237	.03997	.00069	.00065	1.832	.1601	.00064
6.00	68.775	72.901	.04653	.04940	.04660	.00080	.00075	1.612	.1583	.00233
6.50	64.534	68.407	.05682	.05991	.05368	.00091	.00086	1.594	.1567	.00474
7.00	60.829	64.479	.06479	.06889	.06122	.00102	.00097	1.578	.1553	.00715
7.50	57.561	61.019	.07323	.07734	.06919	.00115	.00108	1.563	.1540	.00955
8.00	54.655	57.935	.08213	.08626	.07740	.00128	.00120	1.550	.1528	.01195
8.50	52.054	55.177	.09150	.09564	.08645	.00141	.00133	1.538	.1517	.01435
9.00	49.710	52.692	.10132	.10547	.09573	.00155	.00146	1.527	.1507	.01674
9.50	47.586	50.441	.11159	.11575	.10543	.00170	.00160	1.517	.1498	.01914
10.00	45.652	48.391	.12230	.12648	.11555	.00185	.00174	1.507	.1489	.02153
11.00	42.259	44.794	.14506	.14927	.13705	.00216	.00204	1.490	.1474	.02632
12.00	39.375	41.738	.16956	.17380	.16019	.00251	.00236	1.475	.1460	.03112
13.00	36.893	39.106	.19577	.19995	.18496	.00287	.00270	1.462	.1448	.03591
14.00	34.731	36.815	.22369	.22781	.21133	.00325	.00306	1.450	.1438	.04072
15.00	32.831	34.801	.25327	.25733	.23927	.00365	.00344	1.439	.1426	.04552
16.00	31.146	33.015	.28451	.28852	.26879	.00407	.00384	1.429	.1419	.05034
17.00	29.642	31.420	.31739	.32134	.29985	.00451	.00426	1.420	.1411	.05516
18.00	28.290	29.987	.35189	.35579	.33244	.00497	.00469	1.411	.1403	.05999
19.00	27.067	28.691	.38799	.39183	.36654	.00545	.00514	1.404	.1396	.06482
20.00	25.956	27.514	.42568	.42927	.40214	.00595	.00562	1.396	.1390	.06966
22.00	24.012	25.452	.50575	.50945	.47778	.00700	.00661	1.383	.1379	.07935
24.00	22.365	23.707	.59201	.59582	.55926	.00813	.00767	1.371	.1369	.08906
26.00	20.951	22.208	.68434	.68827	.64648	.00932	.00880	1.360	.1360	.09488
28.00	19.723	20.906	.78265	.78671	.73935	.01059	.00999	1.351	.1352	.09669
30.00	18.646	19.765	.88686	.89093	.83779	.01192	.01124	1.342	.1344	.09857
32.00	17.693	18.755	.99687	.99821	.94171	.01331	.01256	1.334	.1338	.10322
34.00	16.844	17.854	1.1126	1.1141	1.0510	.01478	.01394	1.326	.1332	.10552
36.00	16.082	17.047	1.2340	1.2357	1.1657	.01630	.01538	1.319	.1326	.10458
38.00	15.394	16.317	1.3610	1.3628	1.2857	.01789	.01687	1.313	.1321	.10669
40.00	14.770	15.656	1.4935	1.4955	1.4108	.01954	.01843	1.306	.1316	.10884
45.00	13.435	14.241	1.8485	1.8509	1.7461	.02392	.02256	1.292	.1306	.11437
50.00	12.350	13.091	2.2366	2.2395	2.1127	.02866	.02704	1.280	.1297	.12006
55.00	11.448	12.135	2.6569	2.6604	2.5096	.03375	.03184	1.269	.1289	.12596
60.00	10.688	11.329	3.1087	3.1127	2.9365	.03918	.03696	1.259	.1283	.13210
65.00	10.037	10.639	3.5912	3.5958	3.3922	.04493	.04239	1.250	.1277	.13847
70.00	9.4731	10.041	4.1036	4.1088	3.8762	.05099	.04811	1.241	.1271	.14503
75.00	8.9799	9.5187	4.6453	4.6512	4.3879	.05736	.05411	1.233	.1266	.15175
80.00	8.5447	9.0573	5.2156	5.2222	4.9266	.06402	.06040	1.226	.1262	.15859
90.00	7.8112	8.2798	6.4398	6.4479	6.0829	.07819	.07376	1.213	.1254	.17253

## POLYSTYRENE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	CH	PROTON PATH LENGTH GM/CM2		PATH LENGTH STRAGGLING GM/CM2		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	7.2165	7.7715	7.3316	7.7812	7.3407	.09342	.08814	1.201	.18667
110.00	6.7245	9.2365	8.6853	9.2379	8.6961	.10968	.10347	1.190	.20109
120.00	6.3104	10.741	10.133	10.754	10.145	.12689	.11971	1.180	.21593
130.00	5.9570	12.371	11.671	12.386	11.685	.14501	.13680	1.171	.23109
140.00	5.6517	14.093	13.295	14.110	13.312	.16400	.15472	1.162	.24647
150.00	5.3855	15.904	15.004	15.924	15.022	.18381	.17340	1.154	.26199
160.00	5.1511	17.801	16.794	17.823	16.814	.20440	.19283	1.147	.27766
170.00	4.9433	19.781	18.662	19.805	18.684	.22573	.21296	1.140	.29349
180.00	4.7577	21.842	20.605	21.868	20.630	.24778	.23375	1.133	.30941
190.00	4.5910	23.979	22.622	24.008	22.649	.27050	.25519	1.127	.32539
200.00	4.4405	26.192	24.709	26.224	24.739	.29387	.27724	1.121	.34135
210.00	4.3038	28.477	26.865	28.512	26.898	.31786	.29987	1.115	.35728
220.00	4.1793	30.833	29.087	30.870	29.123	.34244	.32306	1.109	.37317
230.00	4.0653	33.256	31.374	33.296	31.412	.36759	.34679	1.104	.38898
240.00	3.9603	35.746	33.723	35.789	33.763	.39329	.37102	1.099	.40466
250.00	3.8638	38.300	36.132	38.346	36.175	.41950	.39575	1.094	.42020
260.00	3.7746	40.915	38.599	40.964	38.646	.44621	.42095	1.089	.43558
270.00	3.6919	43.591	41.124	43.643	41.173	.47340	.44660	1.085	.45079
280.00	3.6150	46.326	43.704	46.381	43.756	.50105	.47269	1.080	.46582
290.00	3.5433	49.117	46.337	49.176	46.392	.52914	.49919	1.076	.48064
300.00	3.4764	51.963	49.022	52.025	49.080	.55766	.52609	1.072	.49523
310.00	3.4138	54.863	51.737	54.928	51.819	.58658	.55338	1.068	.50972
320.00	3.3552	57.814	54.542	57.883	54.607	.61590	.58104	1.064	.52409
330.00	3.3000	60.816	57.374	60.888	57.442	.64559	.60905	1.060	.53832
340.00	3.2482	63.867	60.282	63.943	60.323	.67565	.63741	1.057	.55239
350.00	3.1993	66.966	63.175	67.045	63.250	.70606	.66409	1.053	.56628
360.00	3.1531	70.112	66.143	70.194	66.221	.73680	.69510	1.050	.58007
370.00	3.1095	73.302	69.152	73.388	69.234	.76787	.72441	1.046	.59380
380.00	3.0682	76.536	72.203	76.626	72.289	.79925	.75401	1.043	.60746
390.00	3.0291	79.812	75.294	79.906	75.383	.83094	.78390	1.040	.62101
400.00	2.9920	83.130	78.425	83.228	78.517	.86292	.81407	1.037	.63444
410.00	2.9567	86.489	81.593	86.590	81.689	.89517	.84450	1.034	.64765
420.00	2.9232	89.886	84.798	89.992	84.898	.92770	.87519	1.031	.66052
430.00	2.8912	93.322	88.040	93.432	88.143	.96050	.90613	1.028	.67307
440.00	2.8608	96.796	91.317	96.909	91.424	.99354	.93730	1.025	.68529
450.00	2.8318	100.31	94.627	100.42	94.738	1.0268	.96871	1.023	.69718
460.00	2.8041	103.85	97.972	103.97	98.086	1.0604	1.0003	1.020	.70873
470.00	2.7776	107.43	101.35	107.55	101.47	1.0941	1.0322	1.017	.71995
480.00	2.7523	111.04	104.76	111.17	104.88	1.1281	1.0642	1.015	.73085
490.00	2.7280	114.69	108.20	114.82	108.32	1.1623	1.0965	1.012	.74141

## POLYSTYRENE

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE CM	PROTON PATH LENGTH GM/CM <sup>2</sup>	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM <sup>2</sup>	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.7048	118.36	111.79	111.79	1.1967	1.1290	1.010	.75166
510.00	2.6626	122.67	115.15	115.30	1.2313	1.1616	1.007	.76159
520.00	2.6612	125.81	118.69	118.83	1.2661	1.1944	1.005	.77121
530.00	2.6407	129.58	122.24	122.39	1.3011	1.2275	1.003	.78053
540.00	2.6211	133.38	125.83	125.97	1.3363	1.2606	1.001	.78955
550.00	2.6021	137.20	129.44	129.59	1.3716	1.2940	.9986	.79828
560.00	2.5840	141.05	133.07	133.22	1.4072	1.3275	.9965	.80672
570.00	2.5665	144.93	136.73	136.89	1.4429	1.3612	.9944	.81487
580.00	2.5496	148.84	140.41	140.57	1.4787	1.3950	.9924	.82274
590.00	2.5334	152.77	144.12	144.29	1.5147	1.4290	.9904	.83034
600.00	2.5178	156.72	147.85	148.02	1.5509	1.4631	.9884	.83767
620.00	2.4882	164.71	155.38	155.56	1.6237	1.5318	.9847	.85155
640.00	2.4607	172.78	163.00	163.19	1.6970	1.6010	.9811	.86444
660.00	2.4349	180.94	170.70	170.90	1.7709	1.6707	.9776	.87638
680.00	2.4109	189.19	178.48	178.68	1.8453	1.7409	.9743	.88743
700.00	2.3885	197.51	186.33	186.55	1.9202	1.8115	.9711	.89763
720.00	2.3674	205.92	194.26	194.48	1.9955	1.8826	.9680	.90702
740.00	2.3477	214.39	202.26	202.49	2.0713	1.9541	.9650	.91566
760.00	2.3291	222.94	210.32	210.55	2.1475	2.0260	.9622	.92359
780.00	2.3117	231.55	218.44	218.69	2.2241	2.0982	.9595	.93084
800.00	2.2952	240.22	226.62	226.88	2.3011	2.1708	.9568	.93745
820.00	2.2798	248.96	234.86	235.13	2.3784	2.2438	.9543	.94348
840.00	2.2652	257.75	243.16	243.43	2.4560	2.3170	.9518	.94897
860.00	2.2514	266.60	251.51	251.79	2.5340	2.3906	.9494	.95396
880.00	2.2383	275.50	259.91	260.20	2.6124	2.4645	.9472	.95850
900.00	2.2260	284.45	268.35	268.65	2.6910	2.5387	.9450	.96261
920.00	2.2144	293.46	276.85	277.16	2.7699	2.6131	.9428	.96635
940.00	2.2033	302.51	285.39	285.71	2.8491	2.6878	.9408	.96972
960.00	2.1929	311.62	293.98	294.31	2.9285	2.7628	.9387	.97279
1000.00	2.1735	330.03	311.35	311.69	3.0882	2.9134	.9347	.97806

THE ELECTRON DENSITY OF POLYSTYRENE IS 3.239E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.327 BEV, AND THE MINIMUM ENERGY LOSS IS 1.9961 MEV/GM/CM<sup>2</sup>

THE EFFECTIVE IONIZATION POTENTIAL IS 62.92 ELECTRON VOLTS

# SARAN

ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL	
					HM	PERCENT
C	6	2	24.7795	12.011	77.30	
H	1	2	2.0795	1.0080	18.30	
CL	17	2	73.1410	35.453	170.0	

DENSITY = 1.6900 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT		PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM2	MEV/CH	MG/CM2	MM	MG/CM2	MM	MG/CM2	MM	PERCENT	PERCENT	
.10	622.88	1052.7	.22709	.00134	.22959	.00136	.01184	.00007	5.156	1.090	0.
.15	541.10	914.46	.31297	.00185	.31565	.00187	.01381	.00008	4.376	.8483	0.
.20	474.71	802.26	.41118	.00243	.41424	.00245	.01640	.00010	3.930	.7391	0.
.30	379.24	640.92	.64687	.00383	.65104	.00385	.02311	.00014	3.519	.6401	0.
.40	321.42	543.19	.93298	.00552	.93856	.00555	.03120	.00018	3.324	.5940	0.
.50	281.11	475.07	1.2646	.00748	1.2717	.00753	.04010	.00024	3.153	.5660	0.
.60	252.73	427.11	1.6368	.00970	1.6478	.00975	.04966	.00029	3.014	.5462	0.
.70	230.59	389.70	2.0510	.01214	2.0619	.01220	.05961	.00035	2.891	.5309	0.
.80	212.17	358.57	2.5010	.01480	2.5140	.01488	.07002	.00041	2.785	.5182	0.
.90	203.18	343.38	2.9801	.01763	2.9952	.01772	.08029	.00048	2.681	.5072	0.
1.00	194.18	328.16	3.4816	.02060	3.4990	.02070	.09000	.00053	2.572	.4970	0.
1.20	172.45	291.44	4.5720	.02705	4.5940	.02718	.11023	.00065	2.399	.4792	0.
1.40	155.67	263.08	5.7897	.03426	5.8167	.03442	.13273	.00079	2.282	.4645	0.
1.60	142.23	240.37	7.1302	.04219	7.1626	.04238	.15771	.00093	2.202	.4521	0.
1.80	131.18	221.69	8.5902	.05083	8.6283	.05106	.18493	.00109	2.143	.4415	.00001
2.00	121.88	205.97	10.167	.06016	10.211	.06042	.21419	.00127	2.098	.4324	.00001
2.20	113.94	192.56	11.859	.07017	11.909	.07047	.24535	.00145	2.060	.4243	.00002
2.40	107.10	181.01	13.664	.08085	13.721	.08119	.27828	.00165	2.028	.4172	.00003
2.60	101.16	170.96	15.579	.09218	15.643	.09256	.31286	.00185	2.000	.4109	.00003
2.80	95.839	161.97	17.603	.10416	17.675	.10459	.34904	.00207	1.975	.4052	.00005
3.00	91.176	154.09	19.736	.11678	19.816	.11725	.38687	.00229	1.952	.4000	.00006
3.20	87.010	147.05	21.974	.13002	22.051	.13054	.42610	.00252	1.931	.3953	.00007
3.40	83.246	140.69	24.317	.14389	24.412	.14445	.46675	.00276	1.912	.3910	.00008
3.60	79.835	134.92	26.763	.15836	26.817	.15897	.50879	.00301	1.894	.3871	.00010
3.80	76.710	129.64	29.310	.17343	29.423	.17410	.55321	.00327	1.877	.3834	.00012
4.00	73.843	124.79	31.958	.18910	32.080	.18932	.59699	.00353	1.861	.3800	.00014
4.20	71.167	120.27	34.709	.20538	34.840	.20616	.64316	.00381	1.846	.3769	.00016
4.40	68.739	116.17	37.561	.22225	37.702	.22309	.69067	.00409	1.832	.3739	.00018
4.60	66.491	112.37	40.509	.23970	40.660	.24059	.73947	.00438	1.819	.3712	.00020
4.80	64.401	108.84	43.557	.25773	43.718	.25868	.78957	.00467	1.806	.3686	.00023

**SARAN**

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CH2	MEV/CM	GM/CH2	CM	GM/CH2	CM	GM/CH2	CM		
5.00	62.452	105.54	.04670	.02763	.04687	.02773	.00084	.00050	1.794	.00025
5.50	58.110	98.206	.05498	.03253	.05518	.03265	.00097	.00058	1.767	.00033
6.00	54.388	91.916	.06385	.03778	.06408	.03792	.00112	.00066	1.742	.00094
6.50	51.158	86.457	.07330	.04337	.07356	.04353	.00127	.00075	1.720	.00180
7.00	48.327	81.672	.08333	.04931	.08362	.04948	.00142	.00084	1.700	.00266
7.50	45.823	77.441	.09393	.05558	.09425	.05577	.00159	.00094	1.682	.00353
8.00	43.591	73.669	.10508	.06218	.10544	.06239	.00176	.00104	1.666	.00457
8.50	41.588	70.284	.11679	.06911	.11719	.06934	.00193	.00114	1.650	.00568
9.00	39.780	67.228	.12905	.07636	.12948	.07662	.00212	.00125	1.636	.00680
9.50	38.136	64.454	.14185	.08394	.14233	.08422	.00231	.00137	1.623	.00792
10.00	36.641	61.923	.15519	.09183	.15570	.09213	.00251	.00148	1.611	.00905
11.00	34.006	57.470	.18345	.10855	.18406	.10891	.00292	.00173	1.588	.01182
12.00	31.760	53.575	.21381	.12693	.21451	.12693	.00336	.00199	1.569	.01537
13.00	29.832	50.416	.24622	.14569	.24701	.14616	.00383	.00227	1.551	.01894
14.00	28.138	47.353	.28065	.16606	.28155	.16659	.00432	.00256	1.535	.02252
15.00	26.644	45.029	.31707	.18762	.31808	.18821	.00484	.00286	1.520	.02611
16.00	25.318	42.787	.35547	.21034	.35659	.21100	.00537	.00318	1.507	.02972
17.00	24.130	40.780	.39583	.23422	.39706	.23495	.00593	.00351	1.495	.03334
18.00	23.061	38.973	.43812	.25924	.43948	.26005	.00652	.00386	1.483	.03698
19.00	22.092	37.335	.48230	.28538	.48379	.28626	.00713	.00422	1.473	.04063
20.00	21.210	35.845	.52837	.31265	.53000	.31361	.00775	.00459	1.463	.04429
22.00	19.663	33.230	.62610	.37048	.62801	.37160	.00908	.00537	1.446	.05166
24.00	18.348	31.009	.73117	.43265	.73338	.43395	.01021	.00621	1.430	.05909
26.00	17.217	29.097	.84344	.49908	.84597	.50058	.01198	.00709	1.416	.06371
28.00	16.232	27.432	.96280	.56971	.96567	.57140	.01355	.00802	1.403	.06742
30.00	15.366	25.969	1.0891	.64447	1.0924	.64638	.01520	.00900	1.392	.06721
32.00	14.599	24.672	1.2224	.72329	1.2260	.72542	.01693	.01002	1.381	.06906
34.00	13.914	23.514	1.3623	.80612	1.3663	.80848	.01874	.01109	1.372	.07098
36.00	13.296	22.471	1.5090	.89291	1.5134	.89532	.02062	.01220	1.363	.07295
38.00	12.740	21.531	1.6623	.98362	1.6671	.98648	.02258	.01330	1.354	.07497
40.00	12.234	20.676	1.8221	1.0782	1.8274	1.0813	.02450	.01456	1.346	.07705
45.00	11.151	18.846	2.2495	1.3311	2.2560	1.3349	.02998	.01774	1.329	.08242
50.00	10.268	17.352	2.7160	1.6671	2.7238	1.6117	.03578	.02117	1.313	.08802
55.00	9.5325	16.110	3.2205	1.9056	3.2296	1.9110	.04198	.02484	1.300	.09385
60.00	8.9106	15.059	3.7619	2.2260	3.7725	2.2322	.04858	.02875	1.288	.09994
65.00	8.3774	14.158	4.3394	2.5677	4.3516	2.5749	.05556	.03287	1.277	.10627
70.00	7.9149	13.376	4.9521	2.9302	4.9659	2.9384	.06290	.03722	1.267	.11281
75.00	7.5097	12.691	5.5992	3.3131	5.6147	3.3223	.07060	.04178	1.257	.11952
80.00	7.1518	12.084	6.2978	3.7159	6.2973	3.7262	.07864	.04653	1.249	.12638
99.00	6.5475	11.065	7.7392	4.5794	7.7605	4.5920	.09571	.05663	1.233	.14045

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/CH2	MEV/CH	GM/CH2	CM	GM/CH2	CM	GM/CH2	CM		
100.00	6.0567	10.236	9.3245	5.5175	9.3501	5.5326	.11403	.06747	1.220	.15481
110.00	5.6500	9.5484	11.031	6.5271	11.061	6.5450	.13354	.07901	1.207	.16954
120.00	5.3072	8.9691	12.853	7.6056	12.888	7.6263	.15415	.09122	1.196	.18472
130.00	5.0143	8.4742	14.788	8.7502	14.828	8.7740	.17583	.10404	1.186	.20025
140.00	4.7611	8.0463	16.830	9.9586	16.876	9.9856	.19851	.11746	1.176	.21603
150.00	4.5400	7.6726	18.976	11.229	19.027	11.259	.22214	.13145	1.167	.23199
160.00	4.3452	7.3435	21.223	12.558	21.280	12.592	.24668	.14597	1.159	.24813
170.00	4.1724	7.0513	23.566	13.944	23.629	13.982	.27208	.16100	1.151	.26446
180.00	4.0180	6.7903	26.002	15.386	26.072	15.427	.29831	.17651	1.144	.28092
190.00	3.8791	6.5558	28.529	16.881	28.606	16.926	.32531	.19249	1.137	.29746
200.00	3.7537	6.3438	31.144	18.428	31.227	18.477	.35307	.20892	1.131	.31403
210.00	3.6398	6.1513	33.843	20.025	33.933	20.079	.38154	.22576	1.124	.33061
220.00	3.5360	5.9758	36.623	21.671	36.721	21.728	.41069	.24301	1.118	.34719
230.00	3.4409	5.8151	39.483	23.363	39.588	23.425	.44049	.26064	1.113	.36372
240.00	3.3535	5.6674	42.420	25.100	42.532	25.167	.47092	.27865	1.107	.38018
250.00	3.2730	5.5313	45.431	26.882	45.551	26.953	.50194	.29701	1.102	.39653
260.00	3.1985	5.4055	48.514	28.706	48.642	28.782	.53354	.31571	1.097	.41275
270.00	3.1295	5.2888	51.667	30.572	51.804	30.653	.56569	.33473	1.092	.42886
280.00	3.0653	5.1803	54.887	32.478	55.033	32.564	.59837	.35407	1.087	.44481
290.00	3.0055	5.0793	58.174	34.422	58.328	34.513	.63155	.37370	1.083	.46060
300.00	2.9496	4.9849	61.524	36.405	61.686	36.501	.66522	.39362	1.078	.47627
310.00	2.8974	4.8965	64.936	38.424	64.107	38.525	.69935	.41382	1.074	.49161
320.00	2.8484	4.8137	68.408	40.478	67.589	40.585	.73393	.43428	1.070	.50685
330.00	2.8023	4.7359	71.939	42.567	72.128	42.693	.76895	.45500	1.065	.52190
340.00	2.7590	4.6627	75.526	44.690	75.725	44.808	.80437	.47596	1.062	.53673
350.00	2.7182	4.5937	79.169	46.845	79.377	46.969	.84020	.49716	1.058	.55133
360.00	2.6797	4.5286	82.865	49.032	83.082	49.131	.87641	.51858	1.055	.56573
370.00	2.6432	4.4671	86.613	51.250	86.840	51.385	.91299	.54023	1.051	.57996
380.00	2.6088	4.4088	90.411	53.498	90.648	53.638	.94992	.56208	1.048	.59401
390.00	2.5761	4.3536	94.259	55.774	94.506	55.921	.98720	.58414	1.045	.60786
400.00	2.5451	4.3012	98.154	58.080	98.412	58.232	1.0248	.60639	1.041	.62149
410.00	2.5157	4.2515	102.10	60.412	102.36	60.570	1.0627	.62884	1.038	.63485
420.00	2.4877	4.2041	106.08	6						

SARAN

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CM2	MEV/CM	GM/CM2	CH	GM/CM2	CH	GM/CM2	CH		
500.00	2.3055	3.8963	139.47	82.528	139.84	82.743	1.4167	.83830	.2595	.74034
510.00	2.2870	3.8650	143.62	85.099	144.19	85.320	1.4573	.86230	.2593	.75044
520.00	2.2692	3.8349	148.20	87.690	148.58	87.918	1.4981	.88644	.2591	.76022
530.00	2.2521	3.8061	152.61	90.301	153.00	90.535	1.5391	.91070	.2589	.76970
540.00	2.2358	3.7784	157.05	92.931	157.46	93.172	1.5803	.93509	.2587	.77887
550.00	2.2200	3.7518	161.53	95.580	161.95	95.820	1.6217	.95959	.2585	.78775
560.00	2.2049	3.7263	166.04	98.248	166.47	98.503	1.6633	.98420	.2583	.79633
570.00	2.1903	3.7017	170.58	100.93	171.02	101.20	1.7051	1.0089	.2581	.80462
580.00	2.1763	3.6780	175.15	103.64	175.60	103.91	1.7471	1.0338	.2579	.81263
590.00	2.1628	3.6552	179.75	106.36	180.21	106.63	1.7892	1.0587	.2578	.82037
600.00	2.1499	3.6333	184.37	109.10	184.85	109.38	1.8315	1.0837	.2576	.82783
620.00	2.1253	3.5917	193.70	114.62	194.20	114.91	1.9167	1.1341	.2572	.84197
640.00	2.1024	3.5530	203.14	120.20	203.67	120.51	2.0024	1.1849	.2568	.85511
660.00	2.0811	3.5170	212.68	125.85	213.23	126.17	2.0887	1.2359	.2564	.86729
680.00	2.0612	3.4834	222.32	131.55	222.89	131.89	2.1756	1.2874	.2560	.87857
700.00	2.0426	3.4519	232.04	137.30	232.63	137.65	2.2631	1.3391	.2557	.88900
720.00	2.0251	3.4225	241.85	143.11	242.47	143.47	2.3510	1.3911	.2553	.89863
740.00	2.0088	3.3949	251.74	148.96	252.38	149.34	2.4394	1.4434	.2549	.90751
760.00	1.9935	3.3690	261.71	154.86	262.38	155.25	2.5283	1.4960	.2545	.91568
780.00	1.9791	3.3447	271.76	160.80	272.45	161.21	2.6176	1.5489	.2541	.92319
800.00	1.9656	3.3218	281.87	166.79	282.59	167.21	2.7073	1.6019	.2537	.93008
820.00	1.9528	3.3003	292.06	172.82	292.80	173.25	2.7974	1.6553	.2533	.93639
840.00	1.9406	3.2800	302.31	178.88	303.07	179.33	2.8878	1.7088	.2529	.94217
860.00	1.9295	3.2608	312.62	184.98	313.41	185.45	2.9787	1.7625	.2525	.94746
880.00	1.9188	3.2428	322.99	191.12	323.81	191.60	3.0698	1.8165	.2521	.95229
900.00	1.9087	3.2257	333.42	197.29	334.26	197.79	3.1613	1.8706	.2517	.95670
920.00	1.8992	3.2096	343.91	203.50	344.78	204.01	3.2531	1.9249	.2513	.96073
940.00	1.8902	3.1944	354.45	209.74	355.34	210.26	3.3452	1.9794	.2508	.96440
960.00	1.8816	3.1799	365.06	216.01	365.97	216.55	3.4376	2.0341	.2503	.96774
1000.00	1.8659	3.1533	386.50	228.70	387.46	229.27	3.6232	2.1439	.2490	.97356

THE ELECTRON DENSITY OF SARAN IS 2.983E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.220 BEV, AND THE MINIMUM ENERGY LOSS IS 1.7236 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 127.22 ELECTRON VOLTS



ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL
C	6	14	94.3447	12.011	77.30
H	1	10	5.6553	1.0080	18.30

DENSITY = 1.2430 GH/CM3

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GM/CM2	MEV/CM	MG/CM2	MM	MG/CM2	MM	MG/CM2	MM			
.10	973.22	1209.7	.13094	.00105	.13173	.00106	.00515	.00004	3.912	.5970	0.
.15	830.45	1042.2	.18619	.00150	.18703	.00150	.00617	.00005	3.301	.4475	0.
.20	731.57	909.34	.24988	.00201	.25022	.00202	.00749	.00006	2.987	.3772	0.
.30	570.03	719.73	.40386	.00325	.40511	.00326	.01086	.00009	2.681	.3099	0.
.40	480.40	597.14	.59375	.00476	.59540	.00479	.01509	.00012	2.534	.2773	0.
.50	413.57	514.07	.81615	.00638	.82026	.00660	.02000	.00016	2.439	.2579	0.
.60	365.69	454.56	1.0752	.00865	1.0778	.00867	.02546	.00020	2.363	.2449	0.
.70	329.33	409.35	1.3626	.01096	1.3659	.01099	.03138	.00025	2.297	.2355	0.
.80	298.75	371.35	1.6808	.01352	1.6847	.01355	.03780	.00030	2.244	.2282	0.
.90	276.65	343.84	2.0277	.01631	2.0322	.01635	.04463	.00036	2.196	.2223	0.
1.00	254.33	316.38	2.4039	.01934	2.4091	.01938	.05192	.00042	2.155	.2174	0.
1.20	223.96	278.39	3.2417	.02608	3.2485	.02613	.06780	.00055	2.087	.2097	0.
1.40	200.75	249.53	4.1848	.03367	4.1934	.03374	.08502	.00068	2.026	.2038	.00001
1.60	182.41	226.73	5.2299	.04207	5.2403	.04216	.10354	.00083	1.976	.1991	.00001
1.80	167.48	208.18	6.3737	.05128	6.3861	.05138	.12333	.00099	1.931	.1951	.00002
2.00	155.05	192.73	7.6134	.06125	7.6281	.06137	.14436	.00116	1.892	.1917	.00003
2.20	144.52	179.64	8.9477	.07198	8.9646	.07212	.16662	.00134	1.859	.1887	.00004
2.40	135.47	168.39	10.376	.08347	10.395	.08363	.19009	.00153	1.829	.1860	.00006
2.60	127.59	158.59	11.895	.09570	11.917	.09588	.21475	.00173	1.802	.1837	.00008
2.80	120.66	149.98	13.505	.10865	13.530	.10885	.24058	.00194	1.778	.1815	.00011
3.00	114.51	142.34	15.205	.12232	15.232	.12254	.26758	.00215	1.757	.1796	.00013
3.20	109.02	135.51	16.992	.13670	17.022	.13695	.29571	.00238	1.737	.1778	.00016
3.40	104.08	129.37	18.867	.15179	18.900	.15206	.32498	.00261	1.719	.1762	.00019
3.60	99.610	123.82	20.829	.16757	20.866	.16787	.35537	.00286	1.703	.1747	.00023
3.80	95.542	118.76	22.877	.18404	22.916	.18436	.39686	.00311	1.688	.1733	.00027
4.00	91.924	114.14	25.009	.20120	25.052	.20154	.44944	.00337	1.674	.1720	.00031
4.20	88.259	109.71	27.229	.21906	27.275	.21943	.45326	.00365	1.662	.1708	.00035
4.40	85.135	105.82	29.535	.23761	29.585	.23801	.48818	.00393	1.650	.1697	.00039
4.60	82.244	102.23	31.918	.25678	31.972	.25721	.52413	.00422	1.639	.1686	.00044
4.80	79.560	98.094	34.390	.27667	34.448	.27713	.56111	.00451	1.629	.1676	.00048

ANTHRACENE

PROTON ENERGY PEV	ENERGY LOSS MEV/CH	PROTON RANGE GM/CH2	PROTON PATH LENGTH CM	PROTON PATH LENGTH GM/CH2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	77.062	0.3694	0.0000	0.0000	0.0060	0.1666	0.0053
5.50	71.507	0.3513	0.0374	0.0374	0.0070	0.1645	0.0067
6.00	66.762	0.3090	0.0508	0.0508	0.0080	0.1626	0.0245
6.50	62.657	0.2783	0.0587	0.0587	0.0092	0.1609	0.0500
7.00	59.070	0.2524	0.0664	0.0664	0.0103	0.1594	0.0753
7.50	55.905	0.2297	0.0756	0.0756	0.0116	0.1580	0.1006
8.00	53.090	0.2084	0.0848	0.0848	0.0129	0.1568	0.1258
8.50	50.569	0.1889	0.0948	0.0948	0.0142	0.1556	0.1511
9.00	48.298	0.1702	0.1046	0.1046	0.0156	0.1546	0.1763
9.50	46.239	0.1523	0.1151	0.1151	0.0171	0.1536	0.2014
10.00	44.364	0.1350	0.1263	0.1263	0.0186	0.1527	0.2266
11.00	41.073	0.1203	0.1497	0.1497	0.0219	0.1511	0.2769
12.00	38.277	0.1071	0.1749	0.1749	0.0253	0.1497	0.3273
13.00	35.868	0.0954	0.2019	0.2019	0.0289	0.1484	0.3777
14.00	33.771	0.0851	0.2306	0.2306	0.0328	0.1473	0.4281
15.00	31.926	0.0762	0.2613	0.2613	0.0369	0.1462	0.4785
16.00	30.291	0.0686	0.2933	0.2933	0.0411	0.1453	0.5290
17.00	28.831	0.0621	0.3275	0.3275	0.0456	0.1444	0.5795
18.00	27.519	0.0565	0.3626	0.3626	0.0502	0.1437	0.6301
19.00	26.330	0.0515	0.3982	0.3982	0.0551	0.1429	0.6808
20.00	25.251	0.4799	0.4382	0.4382	0.0601	0.1423	0.7314
22.00	23.363	0.5203	0.5210	0.5210	0.0707	0.1411	0.8329
24.00	21.763	0.6084	0.6079	0.6079	0.0821	0.1400	0.9345
26.00	20.389	0.7038	0.7040	0.7040	0.0941	0.1391	0.9953
28.00	19.196	0.8083	0.8095	0.8095	0.1069	0.1383	1.0143
30.00	18.149	0.9189	0.9135	0.9135	0.1203	0.1375	1.0339
32.00	17.223	1.0249	1.0263	1.0263	0.1344	0.1368	1.0543
34.00	16.397	1.1438	1.1454	1.1454	0.1492	0.1362	1.0752
36.00	15.656	1.2685	1.2702	1.2702	0.1646	0.1356	1.0967
38.00	14.987	1.3990	1.4008	1.4008	0.1806	0.1351	1.1187
40.00	14.389	1.5350	1.5371	1.5371	0.1972	0.1346	1.1412
45.00	13.083	1.8996	1.9021	1.9021	0.2415	0.1335	1.1989
50.00	12.027	2.2981	2.3012	2.3012	0.2894	0.1326	1.2583
55.00	11.150	2.7297	2.7333	2.7333	0.3408	0.1318	1.3196
60.00	10.410	3.1936	3.1977	3.1977	0.3955	0.1311	1.3839
65.00	9.7768	3.6888	3.6937	3.6937	0.4536	0.1305	1.4503
70.00	9.2283	4.2148	4.2203	4.2203	0.5148	0.1299	1.5186
75.00	8.7483	4.7709	4.7771	4.7771	0.5791	0.1294	1.5885
80.00	8.3248	5.3563	5.3632	5.3632	0.6463	0.1289	1.6597
90.00	7.6109	6.6127	6.6212	6.6212	0.7893	0.1281	1.8047

ANTHRACENE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GH/CM2	PROTON RANGE		PROTON PATH LENGTH GH/CM2 CH		PATH LENGTH STRAGGLING GH/CM2 CH		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GH/CM2	CH	GH/CM2	CH	GH/CM2	CH		
100.00	7.0321	7.9793	6.4194	7.9895	6.4276	.09431	.07587	1.180	.19516
110.00	6.5530	7.4519	7.6041	9.4639	7.6137	.11071	.08907	1.170	.21012
120.00	6.1499	7.0266	8.8077	11.040	8.8319	.12809	.10305	1.160	.22551
130.00	5.8058	6.6443	10.216	12.715	10.229	.14638	.11776	1.151	.24122
140.00	5.5086	6.3172	11.638	14.484	11.652	.16555	.13318	1.143	.25714
150.00	5.2493	6.0249	13.133	16.344	13.149	.18554	.14927	1.135	.27318
160.00	5.0211	5.7612	14.698	18.293	14.717	.20632	.16599	1.128	.28936
170.00	4.8187	5.5297	16.332	20.327	16.353	.22786	.18331	1.121	.30569
180.00	4.6380	5.3245	18.033	22.442	18.055	.25011	.20121	1.114	.32210
190.00	4.4756	5.1532	19.797	24.638	19.821	.27304	.21966	1.108	.33854
200.00	4.3290	5.0009	21.623	26.910	21.649	.29663	.23864	1.102	.35495
210.00	4.1957	4.8633	23.508	29.257	23.538	.32085	.25812	1.097	.37131
220.00	4.0744	4.7444	25.452	31.676	25.484	.34566	.27808	1.091	.38760
230.00	3.9633	4.6424	27.452	34.165	27.486	.37104	.29851	1.086	.40378
240.00	3.8613	4.5566	29.507	36.722	29.543	.39697	.31937	1.081	.41983
250.00	3.7673	4.4827	31.614	39.344	31.653	.42343	.34065	1.076	.43570
260.00	3.6803	4.4207	33.772	42.030	33.813	.45039	.36234	1.072	.45139
270.00	3.5998	4.3645	35.980	44.778	36.024	.47784	.38442	1.067	.46689
280.00	3.5249	4.3144	38.236	47.585	38.283	.50574	.40687	1.063	.48217
290.00	3.4551	4.2697	40.539	50.451	40.588	.53410	.42968	1.059	.49723
300.00	3.3900	4.2337	42.887	53.373	42.939	.56288	.45284	1.055	.51203
310.00	3.3290	4.1979	45.279	56.350	45.334	.59207	.47633	1.051	.52669
320.00	3.2718	4.1669	47.714	59.381	47.772	.62166	.50013	1.047	.54120
330.00	3.2182	4.1402	50.191	62.463	50.252	.65163	.52424	1.043	.55555
340.00	3.1676	4.1174	52.708	65.595	52.771	.68197	.54865	1.040	.56971
350.00	3.1200	4.0982	55.264	68.776	55.331	.71266	.57334	1.036	.58367
360.00	3.0751	4.0823	57.858	72.005	57.928	.74369	.59830	1.033	.59750
370.00	3.0326	4.0696	60.490	75.279	60.563	.77504	.62353	1.030	.61125
380.00	2.9924	4.0596	63.157	78.599	63.233	.80672	.64901	1.026	.62490
390.00	2.9543	4.0512	65.860	81.962	65.939	.83870	.67474	1.023	.63843
400.00	2.9182	4.0433	68.597	85.368	68.679	.87097	.70070	1.020	.65181
410.00	2.8838	4.0364	71.367	88.816	71.453	.90353	.72669	1.017	.66493
420.00	2.8512	4.0304	74.170	92.303	74.259	.93636	.75330	1.014	.67771
430.00	2.8201	4.0254	77.004	95.830	77.096	.96945	.77993	1.012	.69014
440.00	2.7905	4.0215	79.868	99.395	79.964	1.0028	.80676	1.009	.70221
450.00	2.7622	4.0184	82.763	103.00	82.862	1.0364	.83379	1.006	.71394
460.00	2.7352	4.0159	85.686	106.64	85.789	1.0702	.86102	1.004	.72531
470.00	2.7095	4.0138	88.638	110.31	88.744	1.1043	.88843	1.001	.73634
480.00	2.6848	4.0122	91.618	114.02	91.727	1.1386	.91602	.9986	.74703
490.00	2.6612	4.0109	94.624	117.76	94.737	1.1731	.94378	.9962	.75737

ANTHRACENE

PROTON ENERGY MEV	ENERGY LOSS MEV/GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.6386	121.39	121.53	.97172	.1188	.76738
510.00	2.6170	125.19	125.34	.99081	.1187	.77706
520.00	2.5962	129.02	129.17	1.0281	.1186	.78642
530.00	2.5753	132.88	133.04	1.0565	.1184	.79546
540.00	2.5571	136.77	136.94	1.0850	.1183	.80420
550.00	2.5387	140.70	140.86	1.1137	.1182	.81263
560.00	2.5210	144.64	144.81	1.1426	.1181	.82076
570.00	2.5040	148.62	148.79	1.1716	.1179	.82860
580.00	2.4876	152.62	152.80	1.2007	.1178	.83615
590.00	2.4719	156.65	156.83	1.2299	.1177	.84343
600.00	2.4567	160.70	160.89	1.2593	.1176	.85043
620.00	2.4279	168.88	169.08	1.3184	.1173	.86364
640.00	2.4011	177.16	177.37	1.3779	.1171	.87585
660.00	2.3761	185.52	185.74	1.4379	.1169	.88713
680.00	2.3528	193.97	194.20	1.4983	.1166	.89750
700.00	2.3309	202.50	202.74	1.5591	.1164	.90704
720.00	2.3105	211.11	211.36	1.6203	.1162	.91579
740.00	2.2923	219.80	220.05	1.6818	.1159	.92380
760.00	2.2732	228.55	228.82	1.7437	.1157	.93113
780.00	2.2563	237.37	237.65	1.8058	.1155	.93780
800.00	2.2403	246.26	246.54	1.8683	.1152	.94388
820.00	2.2253	255.21	255.50	1.9311	.1150	.94940
840.00	2.2111	264.22	264.52	1.9942	.1148	.95441
860.00	2.1978	273.28	273.59	2.0575	.1145	.95896
880.00	2.1851	282.40	282.72	2.1210	.1143	.96308
900.00	2.1732	291.57	291.90	2.1849	.1141	.96681
920.00	2.1619	300.80	301.14	2.2489	.1138	.97018
940.00	2.1512	310.07	310.42	2.3132	.1136	.97322
960.00	2.1410	319.40	319.76	2.3777	.1133	.97597
1000.00	2.1223	338.26	338.64	2.5074	.1126	.98070

THE ELECTRON DENSITY OF ANTHRACENE IS 3.17E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.319 BEV, AND THE MINIMUM ENERGY LOSS IS 1.9525 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 66.32 ELECTRON VOLTS

## SCINTILLATOR (CESIUM IODIDE)

PROCTON ENERGY MEV	ENERGY LOSS GH/CM2	ELEMENT CS I	ATOMIC NUMBER 55 53	ATOMS/ MOLECULE 1 1	PERCENT BY WEIGHT 51.1548 48.8452	ATOMIC WEIGHT 132.90 126.90	ADJUSTED IONIZATION POTENTIAL 545.2 525.5	PROTON RANGE HG/CM2	PROTON PATH LENGTH MM	MG/CM2	PATH LENGTH STRAGGLING MM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	228.43							.88632	.92269	.04459	.00010	4.832	3.941	0.
.15	206.47							1.1147	1.1528	.04915	.00011	4.264	3.303	0.
.20	189.83							1.3633	1.4053	.05462	.00012	3.887	2.986	0.
.30	162.52							1.9222	2.0426	.06770	.00015	3.428	2.698	0.
.40	141.86							2.5683	2.6354	.08364	.00019	3.174	2.544	0.
.50	126.95							3.2985	3.3815	.10299	.00023	2.855	2.455	0.
.60	114.62							4.1102	4.2109	.12606	.00028	2.994	2.391	0.
.70	105.58							5.0001	5.1200	.15182	.00034	2.965	2.341	0.
.80	97.699							5.9647	6.1051	.17961	.00040	2.942	2.299	0.
.90	89.788							7.0097	7.1720	.20986	.00047	2.926	2.264	0.
1.00	81.874							8.1522	8.3383	.24368	.00054	2.922	2.232	0.
1.20	74.832							10.658	10.895	.31564	.00070	2.897	2.181	0.
1.40	69.117							13.386	13.679	.38843	.00086	2.840	2.141	0.
1.60	64.376							16.320	16.681	.46267	.00103	2.774	2.106	0.
1.80	60.333							19.482	19.895	.53891	.00119	2.709	2.073	0.
2.00	56.838							22.833	23.310	.61740	.00137	2.649	2.043	0.
2.20	53.053							26.382	26.924	.69818	.00155	2.593	2.015	0.
2.40	51.224							30.124	30.735	.78146	.00173	2.543	1.989	0.
2.60	48.889							34.052	34.734	.86797	.00192	2.499	1.965	0.
2.80	46.787							38.161	38.917	.95814	.00212	2.462	1.943	0.
3.00	44.925							42.448	43.280	1.0517	.00233	2.430	1.921	0.
3.20	43.245							46.908	47.817	1.1481	.00255	2.401	1.901	0.
3.40	41.710							51.539	52.527	1.2473	.00277	2.375	1.882	0.
3.60	40.303							56.338	57.408	1.3491	.00299	2.350	1.864	0.
3.80	39.005							61.300	62.453	1.4533	.00322	2.327	1.846	0.
4.00	37.808							66.423	67.661	1.5598	.00346	2.305	1.830	0.
4.20	36.694							71.708	73.034	1.6687	.00370	2.285	1.815	0.
4.40	35.659							77.149	78.563	1.7797	.00395	2.265	1.800	0.
4.60	34.691							82.743	84.247	1.8928	.00420	2.247	1.785	0.
4.80	33.784							88.496	90.092	2.0080	.00445	2.229	1.772	0.

DENSITY = 4.5100 GM/CM3

## SCINTILLATOR (CS-1)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH GM/CM2 CM		PATH LENGTH STRAGGLING GM/CM2 CM PERCENT		MULTIPLY SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM PERCENT		
5.00	32.931	0.9440	.02093	.09609	.02131	.00213	.00047	1.759	0.
5.50	31.005	1.0981	.02435	.11174	.02478	.00243	.00054	1.728	0.
6.00	29.326	1.2615	.02797	.12833	.02846	.00274	.00061	1.701	0.
6.50	27.846	1.4340	.03180	.14584	.03234	.00307	.00068	1.676	0.
7.00	26.529	1.6153	.03582	.16424	.03642	.00340	.00075	1.653	.00001
7.50	25.352	1.8053	.04003	.18353	.04069	.00375	.00083	1.632	.00001
8.00	24.290	2.0040	.04443	.20368	.04516	.00411	.00091	1.612	.00002
8.50	23.327	2.2111	.04903	.22469	.04982	.00448	.00099	1.594	.00003
9.00	22.448	2.4266	.05380	.24655	.05467	.00487	.00108	1.577	.00004
9.50	21.643	2.6503	.05877	.26924	.05970	.00526	.00117	1.562	.00006
10.00	20.898	2.8822	.06391	.29275	.06491	.00566	.00126	1.547	.00009
11.00	19.609	3.3695	.07471	.34215	.07586	.00650	.00144	1.520	.00015
12.00	18.474	3.8883	.08621	.39471	.08752	.00737	.00163	1.497	.00023
13.00	17.487	4.4377	.09840	.45041	.09987	.00828	.00184	1.475	.00033
14.00	16.613	5.0167	.11124	.50908	.11288	.00922	.00205	1.456	.00047
15.00	15.848	5.6355	.12473	.57076	.12655	.01020	.00226	1.438	.00062
16.00	15.146	6.2927	.13886	.63531	.14087	.01122	.00249	1.422	.00080
17.00	14.516	6.9885	.15363	.70274	.15582	.01227	.00272	1.407	.00101
18.00	13.944	7.7226	.16902	.77304	.17141	.01336	.00296	1.394	.00124
19.00	13.420	8.5051	.18504	.84620	.18763	.01449	.00321	1.381	.00149
20.00	12.940	9.344	.20165	.92207	.20445	.01566	.00347	1.370	.00176
22.00	12.088	1.0675	.23670	1.0821	.23994	.01809	.00401	1.348	.00419
24.00	11.355	1.2363	.27412	1.2529	.27781	.02066	.00458	1.330	.00610
26.00	10.714	1.4355	.31386	1.4343	.31803	.02337	.00518	1.313	.00820
28.00	10.153	1.6550	.35588	1.6262	.36057	.02620	.00581	1.298	.01222
30.00	9.6564	1.8947	.40016	1.8282	.40537	.02916	.00647	1.285	.01371
32.00	9.2127	2.0144	.44665	2.0404	.45241	.03224	.00715	1.273	.01520
34.00	8.8138	2.2338	.49530	2.2624	.50163	.03544	.00786	1.262	.01685
36.00	8.4528	2.4629	.54610	2.4941	.55302	.03875	.00859	1.252	.01850
38.00	8.1247	2.7015	.59900	2.7355	.60654	.04218	.00935	1.243	.02020
40.00	7.8248	2.9496	.65401	2.9864	.66218	.04572	.01014	1.234	.02195
45.00	7.1780	4.3260	.80040	3.6542	.81025	.05503	.01220	1.216	.02651
50.00	6.6488	5.0965	.95921	4.3786	.97086	.06499	.01441	1.200	.03131
55.00	6.2041	5.9194	1.1300	5.1577	1.1436	.07555	.01675	1.187	.03635
60.00	5.8250	6.7938	1.3125	5.9898	1.3281	.08669	.01922	1.176	.04165
65.00	5.4972	7.7179	1.5064	6.8739	1.5241	.09840	.02192	1.166	.04718
70.00	5.2121	8.6908	1.7113	7.8082	1.7313	.11066	.02454	1.157	.05292
75.00	4.9607	9.7113	1.9270	8.7918	1.9494	.12343	.02737	1.149	.05886
80.00	4.7375	11.891	2.1533	9.8235	2.1782	.13672	.03032	1.142	.06497
90.00	4.3586		2.6366	12.027	2.6667	.16476	.03653	1.130	.07767

## SCINTILLATOR (CS-1)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAGGLING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	4.0486	14.248	3.1592	.19463	1.120	.09088
110.00	3.7905	15.775	3.7195	.22624	1.112	.10459
120.00	3.5718	16.109	4.3161	.25949	1.105	.11882
130.00	3.3842	15.263	4.9475	.29428	1.098	.13349
140.00	3.2214	14.529	5.6122	.33052	1.093	.14852
150.00	3.0709	13.890	6.3384	.36814	1.089	.16384
160.00	2.9540	13.326	7.1137	.40703	1.084	.17943
170.00	2.8425	12.820	7.8790	.44715	1.081	.19528
180.00	2.7419	12.366	8.6773	.48846	1.077	.21134
190.00	2.6514	11.958	9.4963	.53090	1.074	.22756
200.00	2.5694	11.588	10.346	.57443	1.072	.24390
210.00	2.4949	11.252	11.221	.61897	1.069	.26028
220.00	2.4269	10.945	12.123	.66450	1.067	.27664
230.00	2.3645	10.654	13.048	.71096	1.065	.29294
240.00	2.3067	10.403	13.998	.75832	1.063	.30916
250.00	2.2533	10.162	14.970	.80654	1.061	.32526
260.00	2.2043	9.9415	15.965	.85560	1.059	.34130
270.00	2.1584	9.7365	16.982	.90544	1.058	.35735
280.00	2.1166	9.5458	17.829	.95602	1.056	.37337
290.00	2.0772	9.3680	18.875	1.0073	1.055	.38934
300.00	2.0403	9.2018	19.941	1.0593	1.054	.40524
310.00	2.0056	9.0462	20.154	1.1119	1.053	.42100
320.00	1.9735	8.9003	21.250	1.1651	1.052	.43657
330.00	1.9431	8.7632	22.364	1.2190	1.050	.45194
340.00	1.9144	8.6341	23.496	1.2734	1.049	.46710
350.00	1.8875	8.5124	24.645	1.3284	1.048	.48202
360.00	1.8620	8.3975	25.813	1.3839	1.047	.49674
370.00	1.8379	8.2889	26.995	1.4399	1.047	.51125
380.00	1.8151	8.1861	28.194	1.4964	1.046	.52555
390.00	1.7935	8.0887	29.408	1.5533	1.045	.53963
400.00	1.7730	7.9962	30.637	1.6108	1.044	.55348
410.00	1.7535	7.9083	31.880	1.6686	1.043	.56709
420.00	1.7350	7.8248	33.137	1.7269	1.043	.58046
430.00	1.7174	7.7453	34.408	1.7856	1.042	.59357
440.00	1.7006	7.6695	35.693	1.8446	1.041	.60642
450.00	1.6845	7.5973	36.990	1.9041	1.040	.61902
460.00	1.6693	7.5283	38.300	1.9639	1.040	.63134
470.00	1.6546	7.4625	39.622	2.0240	1.039	.64340
480.00	1.6407	7.3995	40.956	2.0845	1.038	.65519
490.00	1.6273	7.3393	42.302	2.1453	1.038	.66670
			43.659			
			196.90			
			143.78			
			149.45			
			155.18			
			160.97			
			166.83			
			172.73			
			178.70			
			184.71			
			190.78			
			196.90			
			31.547			
			32.791			
			34.050			
			35.321			
			36.605			
			37.901			
			39.210			
			40.531			
			41.863			
			43.206			

## SCINTILLATOR (CS-1)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	CM	PROTON PATH LENGTH GM/CM2	CM	PATH LENGTH STRAGGLING GM/CM2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.6145	7.2816	200.96	203.07	45.027	2.2064	1.087	1.037	.67794
510.00	1.6023	7.2264	207.12	209.29	46.405	2.2678	1.084	1.037	.68891
520.00	1.5906	7.1734	213.32	215.55	47.794	2.3295	1.081	1.036	.69960
530.00	1.5793	7.1226	219.56	221.86	49.193	2.3915	1.078	1.035	.71002
540.00	1.5685	7.0739	225.85	228.21	50.601	2.4538	1.075	1.035	.72017
550.00	1.5581	7.0270	232.13	234.61	52.019	2.5163	1.073	1.034	.73005
560.00	1.5481	6.9821	238.55	241.05	53.447	2.5790	1.070	1.034	.73966
570.00	1.5385	6.9388	244.97	247.53	54.884	2.6421	1.067	1.033	.74900
580.00	1.5293	6.8972	251.42	254.04	56.329	2.7053	1.065	1.032	.75808
590.00	1.5204	6.8572	257.91	260.60	57.783	2.7688	1.062	1.032	.76690
600.00	1.5119	6.8186	264.44	267.20	59.245	2.8325	1.060	1.031	.77546
620.00	1.4957	6.7457	277.61	280.50	62.195	2.9605	1.055	1.030	.79183
640.00	1.4807	6.6780	290.91	293.94	65.174	3.0894	1.051	1.029	.80722
660.00	1.4667	6.6150	304.35	307.51	68.183	3.2189	1.047	1.028	.82166
680.00	1.4537	6.5562	317.91	321.20	71.220	3.3492	1.043	1.027	.83519
700.00	1.4415	6.5013	331.58	335.02	74.284	3.4802	1.039	1.026	.84785
720.00	1.4302	6.4501	345.37	348.95	77.372	3.6118	1.035	1.024	.85967
740.00	1.4195	6.4021	359.27	362.99	80.485	3.7440	1.031	1.023	.87070
760.00	1.4096	6.3572	373.27	377.12	83.620	3.8767	1.028	1.022	.88096
780.00	1.4002	6.3150	387.36	391.36	86.776	4.0099	1.025	1.021	.89051
800.00	1.3914	6.2754	401.55	405.69	89.953	4.1437	1.021	1.020	.89938
820.00	1.3832	6.2382	415.82	420.10	93.149	4.2779	1.018	1.019	.90762
840.00	1.3754	6.2032	430.18	434.60	96.364	4.4126	1.015	1.018	.91524
860.00	1.3681	6.1703	444.63	449.20	99.601	4.5477	1.012	1.017	.92230
880.00	1.3613	6.1393	459.16	463.67	102.85	4.6833	1.010	1.015	.92883
900.00	1.3548	6.1101	473.83	478.69	106.14	4.8192	1.007	1.015	.93486
920.00	1.3487	6.0825	488.50	493.50	109.42	4.9555	1.004	1.013	.94042
940.00	1.3429	6.0565	503.32	508.46	112.74	5.0921	1.001	1.012	.94555
960.00	1.3375	6.0320	518.14	523.43	116.06	5.2291	.9990	1.010	.95027
1000.00	1.3275	5.9869	548.07	553.63	122.76	5.5040	.9942	1.005	.95855

THE ELECTRON DENSITY OF SCINTILLATOR (CS-1) IS 2.504E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 1.988 BEV, AND THE MINIMUM ENERGY LOSS IS 1.2516 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 535.44 ELECTRON VOLTS



## SCINTILLATOR (SODIUM IODIDE)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CH2	ELEMENT NA I	ATOMIC NUMBER 11 53	ATOMS/ MOLECULE 1 1	PERCENT BY WEIGHT 15.3374 84.6626	ATOMIC WEIGHT 22.990 126.90	ADJUSTED IONIZATION POTENTIAL 150.1 525.5	PATH LENGTH		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
								STRAGGLING			
								MG/CH2	MM		
DENSITY = 3.6700 GM/CM3											
.10	263.06	965.42	.61851	.00169	.63629	.00173	.04033	.00011	6.339	2.793	0.
.15	241.58	886.60	.81558	.00222	.83457	.00227	.04450	.00012	5.332	2.275	0.
.20	223.20	812.15	1.0282	.00280	1.0498	.00286	.04945	.00013	4.711	2.065	0.
.30	192.10	705.00	1.5037	.00410	1.5330	.00418	.06136	.00017	4.002	1.907	0.
.40	168.47	618.30	2.0514	.00559	2.0899	.00569	.07584	.00021	3.629	1.844	0.
.50	150.87	553.69	2.6688	.00727	2.7178	.00741	.09388	.00026	3.454	1.806	0.
.60	136.31	500.27	3.3548	.00914	3.4155	.00931	.11513	.00031	3.371	1.777	0.
.70	125.03	458.85	4.1084	.01119	4.1816	.01139	.13879	.00038	3.319	1.751	0.
.80	115.75	424.81	4.9269	.01342	5.0135	.01366	.16425	.00045	3.276	1.728	0.
.90	106.91	392.36	5.8109	.01583	5.9118	.01611	.19171	.00052	3.243	1.707	0.
1.00	98.064	359.90	6.7722	.01845	6.8885	.01877	.22225	.00061	3.226	1.688	0.
1.20	88.967	326.51	8.8820	.02420	9.0315	.02461	.28700	.00078	3.178	1.655	0.
1.40	81.603	299.48	11.196	.03051	11.381	.03101	.35258	.00096	3.098	1.626	0.
1.60	75.542	277.24	13.709	.03735	13.932	.03796	.41985	.00114	3.014	1.599	0.
1.80	70.444	258.53	16.414	.04473	16.677	.04544	.48917	.00133	2.933	1.574	0.
2.00	66.082	242.52	19.304	.05260	19.623	.05343	.56073	.00153	2.860	1.552	0.
2.20	62.414	229.06	22.375	.06097	22.723	.06192	.63450	.00173	2.792	1.530	.00001
2.40	59.203	217.27	25.622	.06982	26.015	.07089	.71082	.00194	2.732	1.511	.00001
2.60	56.364	206.86	29.039	.07913	29.479	.08032	.79066	.00215	2.682	1.493	.00001
2.80	53.824	197.54	32.622	.08889	33.111	.09022	.87369	.00238	2.639	1.476	.00001
3.00	51.550	189.19	36.370	.09910	36.909	.10057	.95968	.00261	2.600	1.460	.00002
3.20	49.512	181.71	40.277	.10975	40.868	.11136	1.0483	.00286	2.565	1.445	.00002
3.40	47.658	174.91	44.343	.12082	44.986	.12258	1.1394	.00310	2.533	1.431	.00003
3.60	46.004	168.83	48.561	.13232	49.259	.13422	1.2329	.00336	2.503	1.418	.00003
3.80	44.444	163.11	52.927	.14422	53.682	.14627	1.3285	.00362	2.475	1.405	.00004
4.00	43.005	157.83	57.448	.15653	58.260	.15875	1.4263	.00389	2.448	1.394	.00004
4.20	41.672	152.94	62.114	.16935	62.985	.17162	1.5261	.00416	2.423	1.382	.00005
4.40	40.434	148.39	66.926	.18236	67.857	.18490	1.6280	.00444	2.399	1.372	.00005
4.60	39.279	144.15	71.884	.19587	72.877	.19857	1.7319	.00472	2.377	1.362	.00006
4.80	38.199	140.19	76.984	.20977	78.039	.21264	1.8378	.00501	2.355	1.352	.00007

## SCINTILLATOR (NAI)

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GH/CH2	MEV/CH	GH/CH2	CM	GH/CH2	CM	GH/CH2	CM		
5.00	37.187	136.47	.08223	.02241	.08335	.02271	.00195	.00053	1.343	.00007
5.50	34.909	128.12	.09595	.02614	.09723	.02649	.00222	.00061	1.321	.00009
6.00	32.933	120.86	.11053	.03012	.11199	.03051	.00251	.00068	1.302	.00012
6.50	31.200	114.50	.12595	.03432	.12759	.03477	.00281	.00077	1.285	.00015
7.00	29.665	108.87	.14221	.03875	.14403	.03925	.00312	.00085	1.269	.00018
7.50	28.297	103.85	.15927	.04340	.16129	.04395	.00345	.00094	1.254	.00022
8.00	27.068	99.338	.17714	.04827	.17937	.04887	.00378	.00103	1.241	.00051
8.50	25.954	95.251	.19580	.05335	.19824	.05402	.00412	.00112	1.228	.00097
9.00	24.940	91.530	.21524	.05865	.21789	.05937	.00448	.00122	1.217	.00144
9.50	24.015	88.135	.23545	.06416	.23833	.06494	.00484	.00132	1.206	.00191
10.00	23.160	84.997	.25644	.06987	.25954	.07072	.00521	.00142	1.196	.00239
11.00	21.699	79.635	.30054	.08189	.30413	.08287	.00598	.00163	1.178	.00334
12.00	20.407	74.892	.34759	.09471	.35168	.09582	.00679	.00185	1.162	.00432
13.00	19.278	70.749	.39753	.10872	.40214	.10958	.00763	.00208	1.148	.00531
14.00	18.284	67.101	.45024	.12288	.45541	.12409	.00851	.00232	1.135	.00632
15.00	17.396	63.845	.50581	.13782	.51155	.13939	.00942	.00257	1.123	.00736
16.00	16.609	60.953	.56406	.15369	.57040	.15542	.01037	.00282	1.112	.00841
17.00	15.897	58.341	.62499	.17030	.63195	.17219	.01135	.00309	1.102	.00949
18.00	15.253	55.978	.68855	.18762	.69616	.18969	.01237	.00337	1.093	.01059
19.00	14.665	53.821	.75480	.20567	.76307	.20792	.01342	.00366	1.084	.01171
20.00	14.127	51.845	.82359	.22441	.83255	.22685	.01451	.00395	1.077	.01284
22.00	13.174	48.348	.96887	.26400	.97927	.26683	.01679	.00457	1.062	.01683
24.00	12.356	45.347	1.1242	.30632	1.1361	.30957	.01919	.00523	1.050	.02174
26.00	11.559	42.767	1.2893	.35131	1.3028	.35500	.02172	.00592	1.039	.02499
28.00	11.034	40.496	1.4640	.39891	1.4792	.40306	.02436	.00664	1.029	.02653
30.00	10.483	38.471	1.6484	.44916	1.6654	.45379	.02712	.00739	1.021	.02812
32.00	9.9909	36.667	1.8419	.50187	1.8607	.50701	.03003	.00817	1.013	.02978
34.00	9.5498	35.048	2.0449	.55719	2.0656	.56284	.03299	.00899	1.005	.03149
36.00	9.1508	33.583	2.2568	.61494	2.2796	.62114	.03609	.00983	.9988	.03326
38.00	8.7868	32.255	2.4779	.67518	2.5027	.68195	.03929	.01071	.9927	.03508
40.00	8.4592	31.045	2.7079	.73785	2.7349	.74520	.04261	.01161	.9871	.03694
45.00	7.7495	28.441	3.3204	.90475	3.3531	.91365	.05134	.01399	.9745	.04179
50.00	7.1683	26.308	3.9858	1.0861	4.0246	1.0966	.06068	.01653	.9642	.04688
55.00	6.6811	24.520	4.7023	1.2813	4.7477	1.2936	.07059	.01923	.9551	.05221
60.00	6.2666	22.999	5.4686	1.4901	5.5209	1.5043	.08106	.02209	.9476	.05780
65.00	5.9094	21.688	6.2834	1.7121	6.3430	1.7283	.09207	.02503	.9410	.06363
70.00	5.5982	20.545	7.1454	1.9470	7.2128	1.9653	.10360	.02823	.9352	.06968
75.00	5.3245	19.541	8.0533	2.1943	8.1288	2.2149	.11563	.03151	.9299	.07792
80.00	5.0819	18.650	9.0064	2.4541	9.0905	2.4770	.12815	.03492	.9252	.08434
90.00	4.6704	17.141	11.043	3.0091	11.146	3.0369	.15457	.04212	.9174	.09561

## SCINTILLATOR (NAI)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	CM	PROTON PATH LENGTH GM/CM2	CM	PATH LENGTH STRAGGLING GM/CM2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	4.3346	13.249	3.6100	13.370	3.6432	.18274	1.367	.9108	.10936
110.00	4.0550	15.615	4.2547	15.757	4.2935	.21257	1.349	.9052	.12358
120.00	3.8185	18.135	4.9415	18.300	4.9864	.24395	1.333	.9006	.13829
130.00	3.6158	20.805	5.6689	20.993	5.7202	.27681	1.319	.8966	.15340
140.00	3.4400	23.617	6.4352	23.830	6.4932	.31106	1.305	.8931	.16884
150.00	3.2880	26.565	7.2385	26.804	7.3035	.34659	1.293	.8900	.18451
160.00	3.1520	29.647	8.0783	29.913	8.1506	.38335	1.282	.8873	.20041
170.00	3.0310	32.854	8.9521	33.148	9.0320	.42131	1.271	.8849	.21656
180.00	2.9228	36.187	9.8602	36.509	9.9481	.46040	1.261	.8828	.23288
190.00	2.8254	39.639	10.801	39.991	10.897	.50057	1.252	.8808	.24933
200.00	2.7373	43.202	11.772	43.585	11.876	.54177	1.243	.8791	.26587
210.00	2.6571	46.880	12.774	47.295	12.887	.58395	1.235	.8775	.28244
220.00	2.5840	50.665	13.805	51.113	13.927	.62707	1.227	.8760	.29898
230.00	2.5159	54.552	14.864	55.037	14.995	.67107	1.219	.8747	.31547
240.00	2.4532	58.541	15.951	59.057	16.092	.71591	1.212	.8735	.33187
250.00	2.3953	62.624	17.064	63.175	17.214	.76152	1.205	.8724	.34814
260.00	2.3466	66.805	18.203	67.392	18.363	.80791	1.199	.8714	.36434
270.00	2.2977	71.077	19.367	71.701	19.537	.85506	1.193	.8704	.38051
280.00	2.2523	75.431	20.554	76.093	20.734	.90291	1.187	.8696	.39662
290.00	2.2099	79.874	21.764	80.574	21.955	.95146	1.181	.8688	.41265
300.00	2.1703	84.404	22.998	85.143	23.200	1.0007	1.175	.8680	.42858
310.00	2.1332	89.014	24.254	89.792	24.467	1.0505	1.170	.8671	.44435
320.00	2.0984	93.701	25.532	94.520	25.755	1.1009	1.165	.8665	.45994
330.00	2.0658	98.465	26.830	99.325	27.064	1.1519	1.160	.8658	.47533
340.00	2.0350	103.30	28.148	104.20	28.393	1.2035	1.155	.8652	.49049
350.00	2.0061	108.22	29.487	109.16	29.744	1.2556	1.150	.8645	.50543
360.00	1.9787	113.19	30.843	114.18	31.112	1.3082	1.146	.8639	.52014
370.00	1.9528	118.24	32.218	119.27	32.498	1.3612	1.141	.8633	.53463
380.00	1.9284	123.35	33.610	124.42	33.903	1.4148	1.137	.8627	.54891
390.00	1.9052	128.53	35.020	129.64	35.325	1.4688	1.133	.8622	.56295
400.00	1.8831	133.76	36.446	134.92	36.763	1.5233	1.129	.8617	.57674
410.00	1.8622	139.05	37.889	140.26	38.218	1.5781	1.125	.8612	.59027
420.00	1.8423	144.41	39.348	145.66	39.690	1.6334	1.121	.8607	.60354
430.00	1.8234	149.82	40.823	151.12	41.177	1.6890	1.118	.8602	.61652
440.00	1.8054	155.29	42.312	156.63	42.679	1.7451	1.114	.8597	.62923
450.00	1.7882	160.81	43.816	162.20	44.196	1.8015	1.111	.8592	.64165
460.00	1.7718	166.38	45.334	167.82	45.727	1.8582	1.107	.8588	.65378
470.00	1.7561	172.00	46.866	173.49	47.272	1.9153	1.104	.8583	.66562
480.00	1.7411	177.67	48.412	179.21	48.831	1.9727	1.101	.8579	.67718
490.00	1.7268	183.39	49.970	184.98	50.403	2.0304	1.098	.8574	.68844

## SCINTILLATOR (NAI)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH CM	GM/CM2	PATH LENGTH STRAGGLING CM	GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
506.00	1.7130	189.16	51.542	190.79	51.987	2.0884	.8570	.69941
510.00	1.6999	194.97	53.125	196.65	53.584	2.1467	.8565	.71009
520.00	1.6873	200.83	54.721	202.56	55.193	2.2053	.8561	.72049
530.00	1.6752	206.72	56.328	208.51	56.814	2.2641	.8556	.73060
540.00	1.6636	212.67	57.947	214.50	58.447	2.3232	.8552	.74042
550.00	1.6524	218.35	59.577	220.53	60.091	2.3826	.8548	.74996
560.00	1.6417	224.67	61.218	226.60	61.745	2.4422	.8544	.75923
570.00	1.6314	230.73	62.869	232.72	63.410	2.5020	.8539	.76822
580.00	1.6215	236.83	64.530	238.87	65.086	2.5621	.8535	.77694
590.00	1.6120	242.96	66.1202	245.05	66.772	2.6224	.8531	.78539
600.00	1.6028	249.13	67.883	251.27	68.467	2.6829	.8527	.79358
620.00	1.5854	261.58	71.275	263.83	71.887	2.8045	.8518	.80920
640.00	1.5693	274.15	74.701	276.51	75.343	2.9269	.8510	.82382
660.00	1.5543	286.86	78.162	289.32	78.833	3.0501	.8502	.83748
680.00	1.5402	299.68	81.656	302.124	82.355	3.1739	.849	.85023
700.00	1.5272	312.61	85.180	315.29	85.909	3.2984	.8485	.86212
720.00	1.5149	325.65	88.734	328.44	89.493	3.4234	.8477	.87317
740.00	1.5035	338.80	92.316	341.69	93.104	3.5491	.8468	.88345
760.00	1.4928	352.04	95.924	355.05	96.743	3.6753	.8460	.89298
780.00	1.4827	365.38	99.557	368.49	100.41	3.8020	.8451	.90182
800.00	1.4733	378.80	103.121	382.02	104.09	3.9291	.8442	.91000
820.00	1.4644	392.30	106.89	395.64	107.80	4.0568	.8434	.91756
840.00	1.4561	405.89	110.60	409.34	111.54	4.1848	.8425	.92455
860.00	1.4482	419.55	114.32	423.11	115.29	4.3133	.8417	.93099
880.00	1.4408	433.31	118.07	436.99	119.07	4.4422	.8408	.93693
900.00	1.4339	447.12	121.83	450.91	122.86	4.5715	.8398	.94240
920.00	1.4273	461.00	125.61	464.90	126.68	4.7011	.8388	.94743
940.00	1.4211	475.00	129.43	479.02	130.52	4.8310	.8389	.95205
960.00	1.4152	489.03	133.25	493.16	134.38	4.9613	.8374	.95629
1000.00	1.4045	517.36	140.97	521.70	142.15	5.2227	.8329	.96372

THE ELECTRON DENSITY OF SCINTILLATOR (NAI) IS 2.572E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.027 BEV, AND THE MINIMUM ENERGY LOSS IS 1.3231 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 423.68 ELECTRON VOLTS

ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL
C	6	1.0	91.5490	12.011	75.10
H	1	1.1	8.4510	1.0080	18.30

DENSITY = 1.0200 GM/CH3

PROTON ENERGY MeV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	Gm/cm2	MeV/cm	MG/CM2	MM	MG/CM2	MM	MG/CM2	MM		
.10	1047.5	1068.5	.12016	.00118	.12083	.00118	.00508	.00005	4.202	0.
.15	896.81	914.74	.17165	.00168	.17236	.00169	.00608	.00006	3.529	.5514
.20	778.96	794.54	.23133	.00225	.23214	.00225	.00738	.00007	3.181	.4124
.30	613.52	625.79	.37636	.00369	.37745	.00370	.01071	.00010	2.836	.0.
.40	507.87	518.03	.55582	.00545	.55726	.00546	.01487	.00015	2.668	.2875
.50	436.28	445.00	.76832	.00753	.77018	.00755	.01972	.00019	2.560	.01487
.60	385.01	392.71	1.0123	.00992	1.0146	.00995	.02510	.00025	2.474	.2417
.70	346.55	353.49	1.2854	.01260	1.2883	.01263	.03094	.00030	2.401	.2304
.90	314.02	320.30	1.5880	.01557	1.5914	.01560	.03726	.00037	2.222	.2222
.90	291.60	297.43	1.9175	.01880	1.9215	.01884	.04397	.00043	2.348	.2158
										.2107
1.00	269.15	274.54	2.2739	.02229	2.2786	.02234	.05102	.00050	2.239	.2064
1.20	236.45	241.18	3.0669	.03007	3.0730	.03013	.06637	.00065	2.160	.1995
1.40	211.67	215.90	3.9609	.03883	3.9686	.03891	.08308	.00081	2.093	.1942
1.60	192.12	195.96	4.9527	.04856	4.9622	.04865	.10108	.00099	2.037	.1899
1.80	176.23	179.76	6.0393	.05921	6.0503	.05932	.12036	.00118	1.989	.1862
2.00	163.03	166.29	7.2181	.07077	7.2313	.07090	.14087	.00138	1.948	.1831
2.20	151.85	154.89	8.4886	.08321	8.5030	.08336	.16259	.00159	1.912	.1803
2.40	142.26	145.10	9.8472	.09654	9.9671	.09671	.18550	.00182	1.880	.1779
2.60	133.91	136.59	11.255	.11073	11.315	.11093	.20959	.00205	1.852	.1757
2.80	126.58	129.11	12.839	.12578	12.851	.12599	.23483	.00230	1.827	.1737
										.00010
3.00	120.09	122.49	14.449	.14166	14.474	.14190	.26122	.00256	1.805	.1719
3.20	114.29	116.57	16.154	.15838	16.182	.15865	.28872	.00283	1.784	.1703
3.40	109.07	111.25	17.943	.17592	17.974	.17621	.31734	.00311	1.766	.1688
3.60	104.35	106.44	19.816	.19428	19.850	.19460	.34706	.00340	1.748	.1674
3.80	100.06	102.06	21.771	.21344	21.807	.21379	.37787	.00370	1.733	.1661
4.00	96.144	98.067	23.807	.23340	23.846	.23379	.40974	.00402	1.718	.1649
4.20	92.400	94.248	25.927	.25419	25.970	.25461	.44284	.00434	1.705	.1638
4.40	89.109	90.891	28.130	.27579	28.176	.27624	.47700	.00468	1.693	.1632
4.60	86.064	87.785	30.408	.29811	30.457	.29860	.51218	.00502	1.682	.1618
4.80	83.238	84.903	32.770	.32128	32.823	.32179	.54838	.00538	1.671	.1608

PILOT 8 SCINT.

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	CH	PROTON PATH LENGTH GM/CM2	CH	PATH LENGTH STRAGGLING GM/CM2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	86.609	82.221	.03521	.03527	.03457	.00059	1.660	.1600	.00049
5.50	74.766	76.261	.04165	.04171	.04089	.00068	1.637	.1580	.00062
6.00	69.779	71.174	.04856	.04761	.04768	.00079	1.617	.1562	.00228
6.50	65.468	66.777	.05595	.05486	.05494	.00090	1.599	.1546	.00464
7.00	61.701	62.935	.06381	.06256	.06266	.00101	1.583	.1532	.00699
7.50	58.380	59.548	.07214	.07072	.07083	.00113	1.568	.1520	.00934
8.00	55.428	56.536	.08092	.07933	.07945	.00126	1.555	.1508	.01169
8.50	52.785	53.840	.09015	.08838	.08851	.00139	1.543	.1498	.01404
9.00	50.404	51.412	.09983	.09787	.09802	.00153	1.532	.1488	.01638
9.50	48.247	49.212	.10996	.10781	.10796	.00168	1.521	.1479	.01873
10.00	46.283	47.209	.12053	.11817	.11834	.00183	1.512	.1470	.02107
11.00	42.837	43.594	.14298	.14017	.14038	.00214	1.495	.1455	.02577
12.00	39.910	40.708	.16715	.16387	.16411	.00248	1.480	.1442	.03046
13.00	37.390	38.138	.19301	.18923	.18950	.00283	1.466	.1430	.03516
14.00	35.196	35.909	.22056	.21623	.21654	.00321	1.454	.1420	.03987
15.00	33.268	33.933	.24975	.24485	.24520	.00361	1.444	.1410	.04458
16.00	31.559	32.190	.28059	.27508	.27547	.00403	1.434	.1402	.04930
17.00	30.032	30.632	.31304	.30690	.30733	.00447	1.424	.1394	.05402
18.00	28.661	29.234	.34709	.34028	.34076	.00492	1.416	.1386	.05876
19.00	27.421	27.969	.38272	.37522	.37573	.00540	1.408	.1380	.06350
20.00	26.294	26.820	.41993	.41169	.41226	.00589	1.401	.1373	.06824
22.00	24.322	24.808	.49898	.48919	.48986	.00693	1.387	.1362	.07775
24.00	22.652	23.105	.58414	.57268	.57346	.00789	1.375	.1352	.08728
26.00	21.218	21.642	.67531	.66206	.66296	.00923	1.365	.1344	.09300
28.00	19.973	20.372	.77239	.75724	.75826	.01048	1.355	.1336	.09478
30.00	18.881	19.259	.87529	.85813	.85927	.01180	1.346	.1329	.09663
32.00	17.915	18.274	.98394	.96465	.96593	.01318	1.338	.1322	.09854
34.00	17.054	17.396	1.0983	1.0767	1.0781	.01463	1.330	.1317	.10051
36.00	16.282	16.608	1.2182	1.1943	1.1958	.01614	1.323	.1311	.10253
38.00	15.585	15.897	1.3436	1.3173	1.3190	.01771	1.317	.1306	.10460
40.00	14.952	15.251	1.4745	1.4456	1.4475	.01935	1.310	.1302	.10671
45.00	13.600	13.872	1.8251	1.7894	1.7917	.02369	1.296	.1291	.11214
50.00	12.500	12.750	2.2086	2.1652	2.1680	.02839	1.284	.1283	.11774
55.00	11.587	11.819	2.6238	2.5724	2.5757	.03344	1.273	.1275	.12353
60.00	10.817	11.033	3.0702	3.0100	3.0139	.03882	1.263	.1269	.12958
65.00	10.157	10.361	3.5469	3.4774	3.4818	.04452	1.253	.1263	.13584
70.00	9.5865	9.7782	4.0533	3.9738	3.9788	.05053	1.245	.1257	.14229
75.00	9.0870	9.2687	4.5846	4.4986	4.5043	.05684	1.237	.1253	.14890
80.00	8.6462	8.8191	5.1522	5.0512	5.0575	.06344	1.230	.1248	.15563
90.00	7.9034	8.0615	6.3621	6.2373	6.2451	.07749	1.216	.1241	.16936

# PILOT B SCIN1.

PRCTON ENERGY MEV	ENERGY LOSS MEV/ GM/CH2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CH2	CM	GM/CH2	CM	GM/CH2	CM		
100.00	7.3013	7.4473	7.5277	7.6878	7.5370	.09260	.09078	1.234	.18328
110.00	6.8031	6.9391	8.7163	9.1079	8.9293	.10871	.10658	1.194	.19748
120.00	6.3838	6.5115	10.405	10.626	10.418	.12578	.12332	1.184	.21210
130.00	6.0260	6.1466	11.985	12.240	12.000	.14375	.14094	1.174	.22705
140.00	5.7171	5.8314	13.654	13.944	13.671	.16298	.15940	1.166	.24222
150.00	5.4475	5.5565	15.410	15.737	15.428	.18223	.17865	1.158	.25754
160.00	5.2103	5.3145	17.245	17.615	17.269	.20265	.19868	1.150	.27301
170.00	4.9999	5.0999	19.144	19.574	19.191	.22381	.21942	1.143	.28864
180.00	4.8121	4.9083	21.144	21.614	21.190	.24568	.24086	1.137	.30437
190.00	4.6434	4.7362	23.237	23.730	23.265	.26822	.26296	1.130	.32016
200.00	4.4910	4.5808	25.381	25.920	25.412	.29140	.28568	1.124	.33595
210.00	4.3527	4.4397	27.597	28.182	27.630	.31520	.30902	1.118	.35172
220.00	4.2266	4.3112	29.880	30.514	29.916	.33958	.33292	1.113	.36744
230.00	4.1113	4.1935	32.230	32.914	32.268	.36453	.35738	1.108	.38310
240.00	4.0053	4.0854	34.643	35.378	34.685	.39002	.38237	1.102	.39864
250.00	3.9074	3.9855	37.119	37.906	37.163	.41602	.40786	1.097	.41404
260.00	3.8171	3.8934	39.655	40.496	39.702	.44252	.43384	1.093	.42930
270.00	3.7333	3.8080	42.249	43.145	42.299	.46950	.46029	1.088	.44440
280.00	3.6555	3.7286	44.900	45.852	44.953	.49693	.48718	1.084	.45932
290.00	3.5830	3.6547	47.607	48.616	47.663	.52480	.51451	1.079	.47404
300.00	3.5153	3.5856	50.366	51.434	50.426	.55309	.54225	1.075	.48855
310.00	3.4520	3.5210	53.178	54.305	53.240	.58179	.57038	1.071	.50296
320.00	3.3926	3.4604	56.039	57.227	56.105	.61087	.59890	1.067	.51727
330.00	3.3368	3.4035	58.957	60.200	59.019	.64034	.62778	1.064	.53145
340.00	3.2843	3.3500	61.908	63.220	61.981	.67016	.65702	1.060	.54548
350.00	3.2348	3.2995	64.912	66.288	64.989	.70033	.68660	1.056	.55934
360.00	3.1881	3.2519	67.962	69.402	68.041	.73083	.71650	1.053	.57311
370.00	3.1440	3.2069	71.055	72.561	71.138	.76166	.74673	1.050	.58682
380.00	3.1022	3.1642	74.192	75.764	74.279	.79280	.77726	1.046	.60048
390.00	3.0626	3.1239	77.369	79.009	77.459	.82424	.80808	1.043	.61403
400.00	3.0250	3.0855	80.587	82.294	80.681	.85597	.83919	1.040	.62748
410.00	2.9893	3.0491	83.843	85.620	83.941	.88798	.87057	1.037	.64071
420.00	2.9554	3.0145	87.138	88.984	87.239	.92026	.90222	1.034	.65362
430.00	2.9231	2.9815	90.470	92.387	90.575	.95280	.93412	1.031	.66621
440.00	2.8923	2.9501	93.838	95.826	93.947	.98559	.96627	1.029	.67848
450.00	2.8629	2.9201	97.241	99.301	97.354	1.0186	.99866	1.026	.69042
460.00	2.8348	2.8915	100.68	102.81	100.80	1.0519	1.0313	1.023	.70204
470.00	2.8080	2.8642	104.15	106.36	104.27	1.0854	1.0641	1.021	.71333
480.00	2.7824	2.8380	107.65	109.93	107.78	1.1191	1.0972	1.018	.72430
490.00	2.7579	2.8130	111.19	113.54	111.32	1.1531	1.1305	1.016	.73495

# PILOT B SCINT.

PROTON ENERGY MEV	ENERGY LOSS HEV/ GM/CH2	PROTON RANGE GH/CH2	CH	PROTON PATH LENGTH GH/CH2	CH	PATH LENGTH STRAGGLING GH/CH2	CH	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.7344	2.7893	117.05	114.89	117.19	1.1872	1.1639	1.013	.1152	.74523
510.00	2.7118	2.7661	120.72	118.49	120.86	1.2216	1.1976	1.011	.1150	.75530
520.00	2.6902	2.7440	124.42	122.12	124.56	1.2561	1.2315	1.008	.1149	.76502
530.00	2.6695	2.7229	128.14	125.63	128.29	1.2908	1.2655	1.006	.1148	.77445
540.00	2.6496	2.7026	131.90	129.31	132.05	1.3257	1.2997	1.004	.1147	.78358
550.00	2.6304	2.6830	135.68	133.02	135.84	1.3608	1.3341	1.002	.1146	.79242
560.00	2.6120	2.6643	139.50	136.76	139.66	1.3961	1.3687	.9997	.1145	.80097
570.00	2.5943	2.6462	143.33	140.52	143.50	1.4315	1.4034	.9976	.1143	.80924
580.00	2.5773	2.6288	147.20	144.31	147.36	1.4671	1.4383	.9956	.1142	.81724
590.00	2.5609	2.6121	151.08	148.12	151.26	1.5026	1.4734	.9936	.1141	.82496
600.00	2.5450	2.5959	155.00	151.96	155.17	1.5387	1.5086	.9916	.1140	.83241
620.00	2.5151	2.5654	162.89	159.70	163.08	1.6110	1.5794	.9878	.1138	.84655
640.00	2.4872	2.5369	170.88	167.53	171.08	1.6838	1.6508	.9842	.1135	.85971
660.00	2.4611	2.5104	178.96	175.45	179.16	1.7571	1.7227	.9808	.1133	.87192
680.00	2.4368	2.4856	187.12	183.45	187.33	1.8310	1.7951	.9774	.1131	.88323
700.00	2.4141	2.4625	195.35	191.52	195.57	1.9053	1.8679	.9742	.1128	.89369
720.00	2.3927	2.4406	203.67	199.90	203.90	1.9801	1.9412	.9711	.1126	.90334
740.00	2.3727	2.4202	212.05	208.12	212.29	2.0553	2.0150	.9681	.1124	.91223
760.00	2.3539	2.4010	220.51	216.18	220.75	2.1309	2.0891	.9653	.1122	.92040
780.00	2.3363	2.3830	229.03	224.54	229.28	2.2069	2.1637	.9625	.1119	.92787
800.00	2.3196	2.3660	237.61	232.95	237.88	2.2833	2.2386	.9599	.1117	.93471
820.00	2.3039	2.3500	246.25	241.42	246.53	2.3601	2.3138	.9573	.1115	.94094
840.00	2.2891	2.3349	254.95	249.95	255.24	2.4372	2.3894	.9549	.1113	.94663
860.00	2.2752	2.3207	263.71	258.54	264.00	2.5146	2.4653	.9525	.1110	.95181
880.00	2.2620	2.3072	272.52	267.18	272.82	2.5924	2.5415	.9502	.1108	.95751
900.00	2.2495	2.2945	281.38	275.86	281.69	2.6704	2.6180	.9480	.1106	.96079
920.00	2.2377	2.2824	290.29	284.50	290.51	2.7487	2.6948	.9458	.1104	.96467
940.00	2.2265	2.2710	299.25	293.38	299.58	2.8274	2.7719	.9438	.1102	.96819
960.00	2.2158	2.2602	308.26	302.22	308.60	2.9063	2.8493	.9417	.1098	.97138
1000.00	2.1962	2.2402	326.49	320.08	326.84	3.0648	3.0047	.9377	.1092	.97689

THE ELECTRON DENSITY OF PILOT B SCINT. IS 5.260E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.333 BEV, AND THE MINIMUM ENERGY LOSS IS 2.0153 MEV/GM/CH2

THE EFFECTIVE IONIZATION POTENTIAL IS 60.34 ELECTRON VOLTS



**ADJUSTED  
ONIZATION  
TENTIAL  
77.30  
18.30**

PERCENT  
WEIGHT  
55.4240  
4.5760

ATOMS/  
MOLECULE  
14  
8.

270M!  
NUNBE  
6 1

3432

DENSITY = 1.1600 GM/CM3

402

# STILBENE

PRCTON ENERGY HEV	ENERGY LOSS HEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	CM	GM/CM2	CM	PERCENT	PATH LENGTH STRAGGLING CM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	75.840	87.975	0.3764	0.3245	0.0060	0.0052	1.600	0.0055	0.0055	0.0055	0.0055
5.50	70.383	81.644	0.4449	0.3835	0.0070	0.0070	1.578	0.0069	0.0069	0.0069	0.0069
6.00	65.720	76.236	0.5176	0.4470	0.0081	0.0070	1.559	0.0052	0.0052	0.0052	0.0052
6.50	61.687	71.557	0.5961	0.5147	0.0092	0.0079	1.542	0.0051	0.0051	0.0051	0.0051
7.00	58.160	67.466	0.6795	0.5857	0.0104	0.0090	1.527	0.0077	0.0077	0.0077	0.0077
7.50	55.048	63.856	0.7677	0.6618	0.0116	0.0100	1.514	0.1033	0.1033	0.1033	0.1033
8.00	52.280	60.645	0.8608	0.7421	0.0129	0.0112	1.501	0.1293	0.1293	0.1293	0.1293
8.50	49.801	57.770	0.9587	0.8278	0.0143	0.0123	1.490	0.1552	0.1552	0.1552	0.1552
9.00	47.567	55.178	1.0613	0.9164	0.0157	0.0136	1.479	0.1852	0.1852	0.1852	0.1852
9.50	45.542	52.829	1.1686	1.0074	0.0172	0.0148	1.470	0.2079	0.2079	0.2079	0.2079
10.00	43.698	50.690	1.2806	1.1039	0.0187	0.0162	1.461	0.2327	0.2327	0.2327	0.2327
11.00	40.461	46.934	1.5183	1.3088	0.0220	0.0189	1.445	0.2844	0.2844	0.2844	0.2844
12.00	37.709	43.742	1.7741	1.5294	0.0254	0.0219	1.431	0.3360	0.3360	0.3360	0.3360
13.00	35.338	40.992	2.0478	1.7653	0.0291	0.0251	1.418	0.3877	0.3877	0.3877	0.3877
14.00	33.274	38.598	2.3322	2.0165	0.0330	0.0284	1.407	0.4393	0.4393	0.4393	0.4393
15.00	31.459	36.492	2.6479	2.2861	0.0370	0.0319	1.397	0.4911	0.4911	0.4911	0.4911
16.00	29.849	34.625	2.9719	2.5637	0.0413	0.0356	1.387	0.5428	0.5428	0.5428	0.5428
17.00	28.411	32.937	3.3170	2.8595	0.0458	0.0395	1.379	0.5946	0.5946	0.5946	0.5946
18.00	27.118	31.457	3.6769	3.1743	0.0505	0.0435	1.371	0.6464	0.6464	0.6464	0.6464
19.00	25.949	30.101	4.0534	3.4994	0.0553	0.0477	1.363	0.6983	0.6983	0.6983	0.6983
20.00	24.887	28.869	4.4465	3.8387	0.0604	0.0521	1.356	0.7502	0.7502	0.7502	0.7502
22.00	23.027	26.711	5.2815	4.5595	0.0711	0.0613	1.344	0.8541	0.8541	0.8541	0.8541
24.00	21.451	24.804	6.1808	5.3253	0.0825	0.0711	1.332	0.9581	0.9581	0.9581	0.9581
26.00	20.098	23.314	7.1433	6.1667	0.0946	0.0815	1.322	1.0204	1.0204	1.0204	1.0204
28.00	18.923	21.951	8.1681	7.0513	0.1074	0.0926	1.313	1.0397	1.0397	1.0397	1.0397
30.00	17.892	20.754	9.2541	7.9776	0.1209	0.1042	1.305	1.0599	1.0599	1.0599	1.0599
32.00	16.979	19.696	1.0400	8.9559	0.1351	0.1164	1.297	1.0807	1.0807	1.0807	1.0807
34.00	16.166	18.753	1.1606	1.0006	0.1499	0.1292	1.290	1.1021	1.1021	1.1021	1.1021
36.00	15.436	17.906	1.2871	1.1096	0.1654	0.1426	1.283	1.1241	1.1241	1.1241	1.1241
38.00	14.777	17.141	1.4194	1.2236	0.1815	0.1564	1.277	1.1460	1.1460	1.1460	1.1460
40.00	14.179	16.448	1.5574	1.3426	0.1982	0.1709	1.271	1.1696	1.1696	1.1696	1.1696
45.00	12.900	14.964	1.9271	1.6613	0.2426	0.2092	1.257	1.2286	1.2286	1.2286	1.2286
50.00	11.860	13.757	2.3313	2.0097	0.2908	0.2507	1.246	1.2893	1.2893	1.2893	1.2893
55.00	10.996	12.755	2.7689	2.3870	0.3424	0.2952	1.235	1.3521	1.3521	1.3521	1.3521
60.00	10.267	11.909	3.2393	2.7925	0.3974	0.3426	1.225	1.4176	1.4176	1.4176	1.4176
65.00	9.6424	11.185	3.7415	3.2297	0.4558	0.3929	1.217	1.4854	1.4854	1.4854	1.4854
70.00	9.1016	10.558	4.2804	3.6900	0.5173	0.4459	1.208	1.5552	1.5552	1.5552	1.5552
75.00	8.6286	10.009	4.8449	4.1766	0.5819	0.5016	1.201	1.6265	1.6265	1.6265	1.6265
80.00	8.2110	9.5248	5.4391	4.6889	0.6494	0.5598	1.194	1.6992	1.6992	1.6992	1.6992
90.00	7.5073	6.7084	6.7145	5.7884	0.7931	0.6837	1.181	1.8472	1.8472	1.8472	1.8472

# STILOENE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
100.00	6.9366	8.1012	6.9752	8.1017	6.9842	.09476	.02169	1.170	.19970
110.00	6.4644	9.5840	8.2621	9.5963	8.2727	.11125	.02590	1.159	.21495
120.00	6.0669	11.180	9.0379	11.194	9.6502	.12870	.11095	1.150	.23063
130.00	5.7276	12.875	11.099	12.892	11.114	.14708	.12680	1.141	.24662
140.00	5.4346	14.666	12.643	14.685	12.659	.16634	.14340	1.133	.26282
150.00	5.1789	16.550	14.267	16.571	14.285	.18643	.16071	1.125	.27914
160.00	4.9539	18.522	15.968	18.546	15.988	.20731	.17872	1.118	.29559
170.00	4.7543	20.581	17.742	20.607	17.765	.22895	.19737	1.111	.31217
180.00	4.5761	22.723	19.589	22.752	19.613	.25130	.21664	1.105	.32863
190.00	4.4169	24.945	21.503	24.977	21.532	.27435	.23651	1.096	.34551
200.00	4.2713	27.246	23.488	27.280	23.517	.29805	.25694	1.093	.36215
210.00	4.1401	29.621	25.536	29.658	25.567	.32238	.27791	1.087	.37873
220.00	4.0205	32.070	27.646	32.110	27.681	.34731	.29940	1.082	.39523
230.00	3.9108	34.589	29.818	34.632	29.855	.37281	.32139	1.076	.41160
240.00	3.8102	37.177	32.059	37.223	32.089	.39887	.34385	1.072	.42783
250.00	3.7275	39.531	34.337	39.580	34.380	.42545	.36677	1.067	.44387
260.00	3.6318	42.550	36.681	42.603	36.726	.45254	.39012	1.062	.45971
270.00	3.5523	45.331	39.078	45.387	39.127	.48011	.41389	1.058	.47535
280.00	3.4725	48.172	41.528	48.232	41.579	.50815	.43806	1.054	.49076
290.00	3.4097	51.073	44.028	51.136	44.083	.53664	.46262	1.049	.50593
300.00	3.3454	54.030	46.578	54.097	46.635	.56556	.48755	1.045	.52064
310.00	3.2853	57.043	49.175	57.113	49.236	.59489	.51283	1.042	.53557
320.00	3.2290	60.111	51.819	60.184	51.883	.62462	.53846	1.038	.55015
330.00	3.1760	63.230	54.508	63.307	54.575	.65473	.56442	1.034	.56454
340.00	3.1262	66.400	57.241	66.481	57.311	.68521	.59070	1.031	.57874
350.00	3.0793	69.619	60.016	69.704	60.090	.71604	.61728	1.027	.59273
360.00	3.0350	72.886	62.833	72.976	62.910	.74722	.64415	1.024	.60657
370.00	2.9931	76.201	65.690	76.294	65.770	.77872	.67131	1.021	.62032
380.00	2.9535	79.560	68.586	79.657	68.670	.81054	.69875	1.018	.63395
390.00	2.9159	82.964	71.521	83.065	71.608	.84267	.72644	1.014	.64745
400.00	2.8803	86.411	74.492	86.516	74.582	.87510	.75490	1.011	.66079
410.00	2.8464	89.829	77.599	90.008	77.593	.90781	.78259	1.009	.67386
420.00	2.8142	93.420	80.742	93.542	80.839	.94079	.81103	1.006	.68657
430.00	2.7836	96.997	83.918	97.115	83.719	.97404	.83969	1.003	.69893
440.00	2.7544	100.60	86.728	100.73	86.833	1.0076	.86858	1.000	.71092
450.00	2.7265	104.25	89.870	104.38	89.979	1.0413	.89768	.9977	.72235
460.00	2.6999	107.93	93.044	108.06	93.156	1.0753	.92699	.9951	.73382
470.00	2.6745	111.65	96.246	111.78	96.364	1.1095	.95650	.9926	.74474
480.00	2.6502	115.40	99.483	115.54	99.603	1.1440	.98620	.9901	.75531
490.00	2.6269	119.19	102.75	119.33	102.87	1.1787	1.0161	.9877	.76582

# STILBENE

PROTON ENERGY PEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	CH	PROTON PATH LENGTH GM/CM2	CH	PATH LENGTH STRAGGLING GM/CM2	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	2.6047	3.0214	123.00	106.17	1.2136	1.0462	.9854	.1201	.77540
510.00	2.5833	2.9967	126.86	109.36	1.2486	1.0764	.9831	.1200	.78494
520.00	2.5629	2.9729	130.74	112.70	1.2839	1.1068	.9809	.1199	.79415
530.00	2.5432	2.9501	134.65	116.08	1.3194	1.1374	.9787	.1198	.80305
540.00	2.5243	2.9282	138.59	119.48	1.3551	1.1682	.9766	.1196	.81163
550.00	2.5062	2.9072	142.56	122.90	1.3909	1.1991	.9745	.1195	.81990
560.00	2.4888	2.8870	146.56	126.35	1.4269	1.2301	.9724	.1194	.82786
570.00	2.4720	2.8675	150.59	129.97	1.4631	1.2613	.9704	.1193	.83554
580.00	2.4559	2.8486	154.64	133.31	1.4995	1.2927	.9685	.1191	.84292
590.00	2.4403	2.8308	158.72	136.83	1.5360	1.3241	.9666	.1190	.85002
600.00	2.4253	2.8134	162.83	140.37	1.5727	1.3558	.9647	.1189	.85685
620.00	2.3970	2.7805	171.12	147.51	1.6465	1.4194	.9611	.1187	.86971
640.00	2.3706	2.7492	179.50	154.74	1.7209	1.4835	.9576	.1184	.88157
660.00	2.3450	2.7213	187.97	162.04	1.7958	1.5481	.9542	.1182	.89249
680.00	2.3230	2.6946	196.53	169.62	1.8712	1.6131	.9510	.1179	.90252
700.00	2.3015	2.6697	205.17	176.87	1.9471	1.6785	.9479	.1177	.91172
720.00	2.2813	2.6463	213.89	184.38	2.0235	1.7444	.9449	.1175	.92013
740.00	2.2624	2.6244	222.68	191.97	2.1003	1.8106	.9421	.1172	.92783
760.00	2.2447	2.6038	231.55	199.61	2.1776	1.8772	.9393	.1170	.93465
780.00	2.2280	2.5845	240.48	207.31	2.2552	1.9441	.9367	.1168	.94124
800.00	2.2123	2.5662	249.48	215.07	2.3332	2.0114	.9341	.1165	.94704
820.00	2.1975	2.5491	258.54	222.88	2.4116	2.0790	.9317	.1163	.95231
840.00	2.1835	2.5329	267.66	230.74	2.4903	2.1468	.9293	.1161	.95708
860.00	2.1704	2.5176	276.84	238.66	2.5694	2.2150	.9270	.1158	.96140
880.00	2.1579	2.5032	286.08	246.62	2.6488	2.2835	.9248	.1156	.96531
900.00	2.1462	2.4895	295.36	254.62	2.7285	2.3522	.9227	.1154	.96885
920.00	2.1350	2.4766	304.70	262.68	2.8085	2.4211	.9207	.1151	.97204
940.00	2.1245	2.4644	314.09	270.77	2.8888	2.4903	.9187	.1149	.97492
960.00	2.1145	2.4528	323.54	278.91	2.9693	2.5598	.9167	.1146	.97752
1000.00	2.0961	2.4315	342.63	295.37	3.1312	2.6993	.9128	.1139	.98197

THE ELECTRON DENSITY OF STILBENE IS 3.145E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.315 BEV, AND THE MINIMUM ENERGY LOSS IS 1.9303 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 68.20 ELECTRON VOLTS



TOLUENE

PRCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	HEV/ GM/CM2	HEV/CH	GM/CM2	CH	GM <sup>2</sup> /CM2	CH	GM/CM2	PERCENT		
5.00	80.314	69.873	.03534	.04063	.03540	.04069	.00059	1.669	.1605	.00050
5.50	74.498	64.814	.04181	.04805	.04187	.04813	.00069	1.645	.1585	.00063
6.00	69.534	60.494	.04875	.05603	.04882	.05612	.00079	1.625	.1568	.00228
6.50	65.242	56.761	.05616	.06456	.05625	.06466	.00090	1.606	.1552	.00465
7.00	61.492	53.498	.06405	.07362	.06415	.07373	.00102	1.590	.1538	.00701
7.50	58.195	50.621	.07240	.08322	.07251	.08335	.00114	1.575	.1525	.00937
8.00	55.246	48.064	.08121	.09334	.08133	.09349	.00127	1.562	.1514	.01172
8.50	52.614	45.774	.09047	.10399	.09061	.10415	.00140	1.550	.1503	.01407
9.00	50.242	43.711	.10019	.11515	.10034	.11533	.00154	1.538	.1493	.01643
9.50	48.094	41.842	.11035	.12684	.11051	.12703	.00169	1.528	.1484	.01878
10.00	46.138	40.140	.12095	.13902	.12113	.13923	.00184	1.518	.1476	.02113
11.00	42.706	37.154	.14347	.16491	.14368	.16515	.00216	1.501	.1461	.02583
12.00	39.789	34.617	.16771	.19277	.16795	.19305	.00250	1.486	.1447	.03053
13.00	37.279	32.433	.19365	.22239	.19393	.22291	.00286	1.472	.1436	.03524
14.00	35.093	30.531	.22128	.25435	.22160	.25471	.00324	1.460	.1425	.03996
15.00	33.172	28.860	.25056	.28800	.25091	.28841	.00364	1.449	.1415	.04468
16.00	31.469	27.378	.28148	.32394	.28188	.32400	.00406	1.439	.1407	.04941
17.00	29.948	26.055	.31403	.36095	.31447	.36146	.00450	1.430	.1399	.05414
18.00	28.581	24.865	.34817	.40020	.34866	.40076	.00496	1.421	.1391	.05888
19.00	27.345	23.790	.38390	.44127	.38444	.44138	.00543	1.413	.1385	.06363
20.00	26.222	22.813	.42121	.48415	.42179	.48482	.00593	1.406	.1378	.06839
22.00	24.256	21.103	.50048	.57526	.50116	.57605	.00698	1.392	.1367	.07791
24.00	22.592	19.655	.58586	.67341	.58666	.67432	.00819	1.380	.1357	.08746
26.00	21.163	18.412	.67727	.77847	.67819	.77952	.00925	1.370	.1348	.09318
28.00	19.922	17.332	.77460	.89035	.77564	.89154	.01055	1.360	.1340	.09496
30.00	18.833	16.385	.87777	1.0089	.87894	1.0103	.01187	1.351	.1333	.09681
32.00	17.870	15.547	.98670	1.1341	.98801	1.1356	.01326	1.343	.1327	.09873
34.00	17.012	14.801	1.1013	1.2659	1.1028	1.2675	.01472	1.335	.1321	.10070
36.00	16.242	14.131	1.2215	1.4040	1.2231	1.4059	.01624	1.328	.1315	.10273
38.00	15.547	13.526	1.3472	1.5485	1.3490	1.5506	.01782	1.321	.1310	.10480
40.00	14.916	12.977	1.4784	1.6994	1.4804	1.7016	.01946	1.315	.1306	.10691
45.00	13.568	11.804	1.8299	2.1034	1.8323	2.1061	.02383	1.301	.1295	.11236
50.00	12.471	10.850	2.2142	2.5451	2.2171	2.5484	.02556	1.287	.1287	.11798
55.00	11.561	10.058	2.6305	3.0236	2.6339	3.0274	.03363	1.277	.1279	.12373
60.00	10.793	9.3895	3.0779	3.5378	3.0818	3.5423	.03904	1.267	.1272	.12981
65.00	10.135	8.8173	3.5537	4.0870	3.5602	4.0922	.04477	1.257	.1266	.13608
70.00	9.5654	8.3219	4.0632	4.6703	4.0683	4.6762	.05081	1.249	.1261	.14254
75.00	9.0572	7.8884	4.5996	5.2869	4.6054	5.2936	.05715	1.241	.1256	.14915
80.00	8.6276	7.5060	5.1645	5.9342	5.1710	5.9436	.06379	1.234	.1252	.15589
90.00	7.8867	6.8614	6.3769	7.3298	6.3848	7.3389	.07790	1.220	.1244	.16963

TOLUENE

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CH2	CH	GM/CH2	CH	GM/CH2	CH		
100.00	7.2861	6.3389	8.8438	7.7054	8.8568	.09309	1.0700	1.238	.18356
110.00	6.7891	5.9065	9.1172	9.1285	10.492	.10928	1.2561	1.197	.19778
120.00	6.3709	5.5427	10.637	10.650	12.241	.12644	1.4533	1.187	.21241
130.00	6.0140	5.2321	12.252	12.267	14.099	.14449	1.6608	1.178	.22737
140.00	5.7057	4.9640	13.958	14.043	16.063	.16341	1.8783	1.169	.24256
150.00	5.4368	4.7300	15.752	15.771	18.127	.18315	2.1052	1.161	.25788
160.00	5.2002	4.5241	17.631	17.652	20.290	.20367	2.3410	1.154	.27336
170.00	4.9903	4.3415	19.592	19.616	22.547	.22493	2.5854	1.147	.28900
180.00	4.8029	4.1785	21.633	21.659	24.895	.24689	2.8379	1.140	.30474
190.00	4.6345	4.0320	23.751	23.779	27.332	.26954	3.0981	1.133	.32054
200.00	4.4825	3.8998	25.942	25.974	29.855	.29282	3.3658	1.127	.33633
210.00	4.3445	3.7797	28.206	28.240	32.460	.31673	3.6406	1.122	.35211
220.00	4.2187	3.6703	30.540	30.576	35.145	.34122	3.9221	1.116	.36784
230.00	4.1036	3.5702	32.941	32.980	37.908	.36628	4.2102	1.111	.38350
240.00	3.9979	3.4782	35.407	35.449	40.747	.39189	4.5044	1.105	.39905
250.00	3.9005	3.3935	37.937	37.982	43.658	.41801	4.8047	1.101	.41446
260.00	3.8105	3.3151	40.528	40.576	46.639	.44462	5.1106	1.096	.42971
270.00	3.7270	3.2425	43.179	43.230	49.690	.47172	5.4220	1.091	.44482
280.00	3.6495	3.1750	45.888	45.942	52.807	.49927	5.7387	1.087	.45974
290.00	3.5768	3.1118	48.652	48.710	55.988	.52726	6.0605	1.082	.47446
300.00	3.5093	3.0531	51.472	51.533	59.233	.55568	6.3871	1.078	.48897
310.00	3.4461	2.9981	54.345	54.409	62.539	.58450	6.7184	1.074	.50339
320.00	3.3869	2.9466	57.268	57.336	65.903	.61371	7.0541	1.070	.51769
330.00	3.3312	2.8981	60.242	60.313	69.325	.64330	7.3942	1.067	.53187
340.00	3.2788	2.8526	63.266	63.340	72.805	.67325	7.7385	1.063	.54590
350.00	3.2295	2.8096	66.335	66.413	76.337	.70355	8.0868	1.059	.55976
360.00	3.1829	2.7691	69.451	69.532	79.922	.73418	8.4389	1.056	.57353
370.00	3.1388	2.7308	72.611	72.696	83.559	.76514	8.7948	1.053	.58724
380.00	3.0972	2.6945	75.815	75.903	87.245	.79641	9.1542	1.049	.60089
390.00	3.0577	2.6602	79.041	79.133	90.981	.82799	9.5171	1.046	.61445
400.00	3.0202	2.6275	82.348	82.444	94.763	.85985	9.8833	1.043	.62790
410.00	2.9846	2.5966	85.675	85.775	98.591	.89199	1.0253	1.040	.64112
420.00	2.9507	2.5671	89.040	89.144	102.46	.92441	1.0625	1.037	.65403
430.00	2.9184	2.5390	92.444	92.552	106.38	.95709	1.1001	1.034	.66661
440.00	2.8877	2.5123	95.885	95.996	110.34	.99002	1.1379	1.031	.67887
450.00	2.8584	2.4868	99.362	99.477	114.34	1.0232	1.1761	1.029	.69081
460.00	2.8304	2.4625	102.87	102.99	118.38	1.0566	1.2145	1.026	.70243
470.00	2.8037	2.4392	106.42	106.54	122.47	1.0902	1.2531	1.023	.71371
480.00	2.7781	2.4170	110.00	110.13	126.58	1.1241	1.2921	1.021	.72466
490.00	2.7536	2.3957	113.61	113.74	130.74	1.1582	1.3312	1.018	.73532

PROTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/CH2	MEV/CM	GM/CH2	CM	GM/CH2	CM	GM/CH2	CM		
500.00	2.7302	2.3753	117.26	134.78	117.39	134.93	1.1925	1.3706	1.016	.74565
510.00	2.7077	2.3557	120.93	139.00	121.07	139.16	1.2269	1.4103	1.013	.75565
520.00	2.6862	2.3370	124.63	143.26	124.78	143.42	1.2656	1.4501	1.011	.76538
530.00	2.6655	2.3190	128.37	147.55	128.51	147.72	1.2965	1.4902	1.009	.77480
540.00	2.6456	2.3017	132.13	151.87	132.28	152.05	1.3315	1.5305	1.007	.78392
550.00	2.6265	2.2851	135.92	156.23	136.07	156.41	1.3668	1.5710	1.004	.79276
560.00	2.6081	2.2691	139.73	160.61	139.89	160.80	1.4022	1.6117	1.002	.80131
570.00	2.5905	2.2537	143.58	165.03	143.74	165.22	1.4377	1.6526	1.000	.80957
580.00	2.5735	2.2389	147.45	169.48	147.61	169.67	1.4735	1.6937	.9982	.81756
590.00	2.5571	2.2247	151.34	173.95	151.51	174.15	1.5094	1.7349	.9962	.82528
600.00	2.5413	2.2109	155.26	178.46	155.44	178.66	1.5454	1.7763	.9942	.83273
620.00	2.5114	2.1849	163.17	187.55	163.36	187.76	1.6179	1.8597	.9905	.84685
640.00	2.4836	2.1607	171.17	196.74	171.35	196.97	1.6910	1.9437	.9868	.85999
660.00	2.4576	2.1381	179.25	206.04	179.46	206.27	1.7647	2.0284	.9833	.87219
680.00	2.4334	2.1170	187.42	215.43	187.64	215.67	1.8388	2.1136	.9800	.88349
700.00	2.4107	2.0973	195.67	224.91	195.89	225.17	1.9134	2.1993	.9768	.89394
720.00	2.3894	2.0788	204.00	234.48	204.23	234.75	1.9885	2.2856	.9737	.90358
740.00	2.3694	2.0614	212.39	244.13	212.63	244.41	2.0640	2.3724	.9707	.91246
760.00	2.3507	2.0451	220.86	253.86	221.11	254.15	2.1399	2.4597	.9678	.92062
780.00	2.3331	2.0298	229.39	263.67	229.65	263.97	2.2162	2.5474	.9650	.92809
800.00	2.3165	2.0153	237.99	273.53	238.25	273.86	2.2929	2.6355	.9624	.93491
820.00	2.3008	2.0017	246.64	283.50	246.92	283.81	2.3700	2.7241	.9598	.94114
840.00	2.2861	1.9880	255.35	293.51	255.64	293.84	2.4474	2.8131	.9574	.94681
860.00	2.2721	1.9767	264.12	303.59	264.42	303.93	2.5251	2.9024	.9550	.95198
880.00	2.2589	1.9653	272.94	313.73	273.25	314.09	2.6031	2.9921	.9527	.95667
900.00	2.2465	1.9544	281.82	323.93	282.13	324.28	2.6815	3.0822	.9504	.96094
920.00	2.2347	1.9442	290.74	334.18	291.06	334.55	2.7601	3.1726	.9483	.96481
940.00	2.2235	1.9345	299.71	344.50	300.04	344.88	2.8390	3.2633	.9462	.96832
960.00	2.2129	1.9255	308.74	354.87	309.08	355.26	2.9182	3.3543	.9442	.97151
980.00	2.2034	1.9168	317.98	365.24	318.34	365.65	3.0074	3.4461	.9422	.97470
1000.00	2.1934	1.9082	327.34	375.64	327.74	376.25	3.0974	3.5372	.9401	.97700

THE ELECTRON DENSITY OF TOLUENE IS  $3.263 \times 10^{23}$  ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.330 BEV, AND THE MINIMUM ENERGY LOSS IS 2.0132 MEV/GM/CM<sup>2</sup>

THE EFFECTIVE IONIZATION POTENTIAL IS 61.72 ELECTRON VOLTS



ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL
107.87	465.0
79.909	348.5

DENSITY = 6.4730 GM/CM3

410

## SILVER BROMIDE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2 CM	PROTON PATH LENGTH GM/CM2 CM	PATH LENGTH STRAGGLING GM/CM2 CM PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	38.379	248.43	.08167	.01262	.00171	0.
5.50	36.038	233.28	.09513	.01470	.00195	.00001
6.00	34.014	220.17	.10941	.01690	.00221	.00001
6.50	32.235	208.66	.12455	.01924	.00247	.00002
7.00	30.670	198.53	.14043	.02169	.00275	.00004
7.50	29.269	189.46	.15712	.02427	.00304	.00005
8.00	28.007	181.29	.17459	.02697	.00333	.00007
8.50	26.862	173.88	.19283	.02979	.00364	.00010
9.00	25.819	167.13	.21182	.03272	.00396	.00013
9.50	24.865	160.95	.23156	.03577	.00428	.00017
10.00	23.986	155.26	.25204	.03894	.00462	.00021
11.00	22.435	145.22	.29517	.04560	.00531	.00032
12.00	21.095	136.55	.34116	.05271	.00605	.00045
13.00	19.927	128.99	.38995	.06024	.00681	.00060
14.00	18.895	122.31	.44151	.06821	.00762	.00079
15.00	17.977	116.36	.49579	.07659	.00846	.00099
16.00	17.168	111.13	.55273	.08539	.00934	.00161
17.00	16.424	106.31	.61230	.09459	.01025	.00254
18.00	15.753	101.97	.67452	.10420	.01119	.00368
19.00	15.142	98.016	.73930	.11421	.01216	.00508
20.00	14.583	94.394	.80657	.12460	.01316	.00663
22.00	13.594	87.993	.94871	.14656	.01527	.01084
24.00	12.746	82.504	1.1008	.17006	.01749	.01512
26.00	12.011	77.747	1.2625	.19504	.01983	.01802
28.00	11.367	73.576	1.4337	.22149	.02228	.01946
30.00	10.796	69.885	1.6144	.24940	.02485	.02101
32.00	10.287	66.590	1.8042	.27873	.02752	.02259
34.00	9.8338	63.654	2.0031	.30945	.03030	.02423
36.00	9.4241	61.002	2.2109	.34155	.03318	.02592
38.00	9.0524	58.596	2.4275	.37502	.03616	.02766
40.00	8.7132	56.401	2.6528	.40982	.03924	.02945
45.00	7.9840	51.681	3.2530	.50254	.04735	.03412
50.00	7.3828	47.789	3.9049	.60325	.05604	.03903
55.00	6.8794	44.530	4.6070	.71172	.06528	.04419
60.00	6.4514	41.760	5.3580	.82775	.07505	.04961
65.00	6.0827	39.373	6.1566	.95111	.08534	.05527
70.00	5.7614	37.294	7.0017	1.0817	.09612	.06114
75.00	5.4792	35.467	7.8920	1.2192	.10737	.06720
80.00	5.2290	33.847	8.8264	1.3636	.11908	.07344
90.00	4.8049	31.102	10.824	1.6721	.14385	.08636

## SILVER BROMIDE

PROTON ENERGY MEV	ENERGY LOSS MEV/CH2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GH/CH2	CM	GM/CH2	CM	GM/CH2	PERCENT		
100.00	4.4588	12.875	1.9891	12.986	2.0062	.17029	.02631	.8561	.09977
110.00	4.1707	15.177	2.3447	15.307	2.3648	.19830	.03064	.8504	.11366
120.00	3.9284	17.629	2.7234	17.779	2.7467	.22777	.03519	.8456	.12803
130.00	3.7178	20.225	3.1245	20.396	3.1510	.25865	.03996	.8415	.14280
140.00	3.5368	22.962	3.5473	23.156	3.5773	.29090	.04494	.8378	.15791
150.00	3.3784	25.833	3.9908	26.050	4.0244	.32440	.05012	.8346	.17327
160.00	3.2386	28.831	4.4541	29.073	4.4915	.35910	.05548	.8318	.18688
170.00	3.1143	31.957	4.9370	32.225	4.9783	.39493	.06101	.8293	.20475
180.00	3.0030	35.201	5.4381	35.495	5.4835	.43185	.06672	.8270	.22084
190.00	2.9029	38.561	5.9573	38.882	6.0068	.46979	.07258	.8251	.23709
200.00	2.8104	42.034	6.4937	42.383	6.5476	.50873	.07859	.8233	.25345
210.00	2.7281	45.619	7.0476	45.997	7.1059	.54867	.08476	.8214	.26987
220.00	2.6530	49.305	7.6170	49.712	7.6799	.58950	.09107	.8199	.28628
230.00	2.5841	53.097	8.2029	53.535	8.2706	.63117	.09751	.8184	.30265
240.00	2.5208	56.984	8.8034	57.454	8.8759	.67365	.10407	.8171	.31894
250.00	2.4624	60.965	9.4183	61.466	9.4958	.71690	.11075	.8159	.33512
260.00	2.4084	65.037	10.047	65.571	10.130	.76089	.11755	.8147	.35123
270.00	2.3582	69.198	10.690	69.766	10.778	.80559	.12445	.8137	.36734
280.00	2.3116	73.444	11.346	74.046	11.439	.85097	.13147	.8127	.38340
290.00	2.2661	77.775	12.015	78.412	12.114	.89700	.13858	.8117	.39939
300.00	2.2275	82.190	12.697	82.861	12.801	.94366	.14578	.8109	.41529
310.00	2.1894	86.680	13.391	87.388	13.500	.99091	.15308	.8101	.43107
320.00	2.1537	91.247	14.097	91.992	14.212	1.0387	.16047	.8093	.44671
330.00	2.1202	95.888	14.814	96.670	14.934	1.0871	.16795	.8085	.46218
340.00	2.0887	100.60	15.542	101.42	15.668	1.1360	.17550	.8078	.47748
350.00	2.0589	105.40	16.283	106.26	16.415	1.1854	.18313	.8075	.49258
360.00	2.0308	110.25	17.032	111.15	17.171	1.2353	.19084	.8068	.50746
370.00	2.0043	115.11	17.782	116.04	17.927	1.2857	.19863	.8062	.52210
380.00	1.9791	120.08	18.551	121.06	18.702	1.3365	.20648	.8056	.53650
390.00	1.9553	125.12	19.330	126.14	19.487	1.3878	.21440	.8049	.55064
400.00	1.9327	130.22	20.118	131.28	20.281	1.4395	.22238	.8044	.56452
410.00	1.9112	135.38	20.915	136.48	21.084	1.4915	.23042	.8038	.57813
420.00	1.8908	140.60	21.721	141.74	21.897	1.5440	.23853	.8032	.59148
430.00	1.8714	145.87	22.535	147.05	22.718	1.5968	.24669	.8027	.60456
440.00	1.8529	151.20	23.358	152.42	23.547	1.6500	.25491	.8022	.61736
450.00	1.8352	156.57	24.189	157.84	24.384	1.7036	.26318	.8017	.62989
460.00	1.8184	162.00	25.027	163.31	25.229	1.7574	.27150	.8011	.64213
470.00	1.8023	167.48	25.873	168.83	26.082	1.8116	.27988	.8006	.65409
480.00	1.7869	173.00	26.727	174.40	26.943	1.8661	.28830	.8001	.66577
490.00	1.7722	178.58	27.588	180.02	27.810	1.9210	.29676	.7996	.67716

# SILVER BROMIDE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	PATH LENGTH STRAIGHTENING GM/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.7581	184.19	185.68	1.9761	.7992	.68827
510.00	1.7446	189.86	191.39	2.0314	.7987	.69910
520.00	1.7316	195.56	197.14	2.0871	.7982	.70964
530.00	1.7192	201.31	202.93	2.1430	.7977	.71989
540.00	1.7073	207.10	208.76	2.1992	.7973	.72987
550.00	1.6958	212.93	214.64	2.2556	.7968	.73957
560.00	1.6848	218.79	220.55	2.3122	.7964	.74900
570.00	1.6742	224.70	226.50	2.3691	.7959	.75815
580.00	1.6641	230.64	232.49	2.4262	.7954	.76704
590.00	1.6543	236.61	238.51	2.4835	.7950	.77566
600.00	1.6449	242.63	244.57	2.5410	.7945	.78402
620.00	1.6270	254.75	256.79	2.6566	.7936	.79998
640.00	1.6104	267.01	269.14	2.7730	.7927	.81495
660.00	1.5950	279.38	281.61	2.8900	.7918	.82896
680.00	1.5806	291.88	294.20	3.0078	.7909	.84207
700.00	1.5672	304.48	306.91	3.1261	.7900	.85431
720.00	1.5546	317.19	319.71	3.2451	.7891	.86571
740.00	1.5429	330.17	332.79	3.3646	.7885	.87634
760.00	1.5318	343.08	345.80	3.4847	.7876	.88621
780.00	1.5215	356.08	358.91	3.6052	.7868	.89538
800.00	1.5118	369.12	372.04	3.7262	.7851	.90359
820.00	1.5027	382.29	385.32	3.8477	.7843	.91177
840.00	1.4941	395.54	398.67	3.9696	.7833	.91907
860.00	1.4861	408.67	412.09	4.0919	.7824	.92551
880.00	1.4785	422.26	425.59	4.2146	.7814	.93204
900.00	1.4713	435.71	439.14	4.3376	.7803	.93779
920.00	1.4646	449.12	452.65	4.4610	.7798	.94365
940.00	1.4582	462.73	466.36	4.5847	.7788	.94997
960.00	1.4522	476.40	480.13	4.7088	.7769	.95245
1000.00	1.4411	504.06	507.99	4.9578	.7745	.96033

THE ELECTRON DENSITY OF SILVER BROMIDE IS 2.631E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.032 BEV, AND THE MINIMUM ENERGY LOSS IS 1.3570 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 411.14 ELECTRON VOLTS

ELEMENT	ATOMIC NUMBER	ATOMS/ MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL
AG	47	1	75.2636	107.87	465.0
CL	17	1	24.7364	35.453	170.0

PRCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION	
	GM/CH2	MEV/CH	MG/CH2	MM	MG/CH2	MM	MG/CH2	MM			
1.10	307.25	1708.3	.58461	.00105	.60080	.00108	.03399	.00006	5.657	2.695	0.
1.15	272.92	1517.5	.75623	.00136	.77336	.00139	.03769	.00007	4.874	2.216	0.
1.20	244.67	1360.3	.94749	.00170	.96677	.00174	.04215	.00008	4.359	1.994	0.
1.30	203.09	1129.2	1.3916	.00250	1.4171	.00255	.05353	.00010	3.777	1.799	0.
1.40	176.56	981.70	1.9133	.00344	1.9467	.00350	.06909	.00012	3.549	1.715	0.
1.50	157.25	874.28	2.5050	.00451	2.5475	.00458	.08742	.00016	3.432	1.666	0.
1.60	142.49	792.23	3.1640	.00569	3.2165	.00579	1.0778	.00019	3.351	1.631	0.
1.70	130.37	724.86	3.8872	.00699	3.9506	.00711	1.2997	.00023	3.290	1.604	0.
1.80	121.33	674.43	4.6722	.00840	4.7472	.00854	1.5360	.00028	3.236	1.581	0.
1.90	116.35	646.92	5.5009	.00939	5.5881	.01005	1.7748	.00032	3.176	1.561	0.
1.00	111.40	619.37	6.3674	.01145	6.4672	.01163	.20162	.00036	3.118	1.542	0.
1.20	100.63	559.53	8.1237	.01481	8.3586	.01503	.25165	.00045	3.011	1.507	0.
1.40	92.098	512.07	10.285	.01850	10.439	.01877	.30395	.00055	2.912	1.472	0.
1.60	85.321	474.38	12.516	.02251	12.698	.02284	.35835	.00064	2.822	1.440	0.
1.80	79.522	442.14	14.914	.02682	15.128	.02721	.41539	.00075	2.746	1.410	0.
2.00	74.596	414.75	17.482	.03144	17.727	.03188	.47613	.00086	2.686	1.383	0.
2.20	70.352	391.16	20.209	.03635	20.487	.03685	.54004	.00097	2.636	1.358	0.
2.40	66.657	370.61	23.097	.04154	23.409	.04210	.60674	.00109	2.592	1.335	0.
2.60	63.407	352.55	26.139	.04701	26.487	.04764	.67595	.00122	2.552	1.314	0.
2.80	60.488	336.31	29.333	.05276	29.718	.05345	.74750	.00134	2.515	1.295	.00001
3.00	57.892	321.88	32.677	.05877	33.099	.05953	.82129	.00148	2.481	1.277	.00001
3.20	55.550	308.56	36.163	.06534	36.625	.06587	.89718	.00161	2.450	1.261	.00001
3.40	53.418	297.01	39.798	.07158	40.300	.07248	.97512	.00175	2.420	1.245	.00001
3.60	51.468	286.16	43.372	.07837	44.115	.07934	1.0551	.00190	2.392	1.231	.00001
3.80	49.677	276.20	47.485	.08540	48.070	.08646	1.1369	.00204	2.365	1.218	.00002
4.00	48.024	267.02	51.536	.09269	52.164	.09382	1.2207	.00220	2.340	1.205	.00002
4.20	46.496	256.52	55.727	.10023	56.400	.10144	1.3063	.00235	2.316	1.194	.00002
4.40	45.078	250.63	60.050	.10850	60.768	.10930	1.3938	.00251	2.294	1.183	.00002
4.60	43.758	243.29	64.507	.11602	65.272	.11740	1.4830	.00267	2.272	1.172	.00003
4.80	42.525	236.44	69.097	.12428	69.910	.12574	1.5740	.00283	2.251	1.162	.00004

## SILVER CHLORIDE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH GM/CM2 CM		PATH LENGTH STRAGGLING GM/CM2 CM		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
5.00	41.369	0.7382	0.1528	0.7468	0.1343	0.0167	0.0030	1.153	.00004
5.50	38.769	0.8618	0.1550	0.8717	0.1568	0.0191	0.0034	1.132	.00006
6.00	36.523	0.9935	0.1787	1.0047	0.1807	0.0216	0.0039	1.113	.00008
6.50	34.557	1.1329	0.2039	1.1455	0.2060	0.0242	0.0043	1.096	.00010
7.00	32.837	1.2800	0.2302	1.2940	0.2327	0.0269	0.0048	1.081	.00013
7.50	31.302	1.4345	0.2580	1.4500	0.2608	0.0296	0.0053	1.067	.00016
8.00	29.923	1.5964	0.2871	1.6134	0.2902	0.0325	0.0059	1.055	.00028
8.50	28.675	1.7656	0.3175	1.7842	0.3209	0.0355	0.0064	1.043	.00044
9.00	27.540	1.9419	0.3493	1.9622	0.3529	0.0386	0.0069	1.033	.00061
9.50	26.504	2.1253	0.3822	2.1473	0.3862	0.0417	0.0075	1.023	.00078
10.00	25.551	2.3157	0.4165	2.3394	0.4208	0.0450	0.0081	1.014	.00095
11.00	23.874	2.7172	0.4887	2.7445	0.4936	0.0517	0.0093	0.978	.00157
12.00	22.427	3.1457	0.5650	3.1770	0.5714	0.0587	0.0106	0.935	.00258
13.00	21.172	3.6008	0.6476	3.6361	0.6540	0.0662	0.0119	0.907	.00361
14.00	20.063	4.0820	0.7342	4.1215	0.7413	0.0739	0.0133	0.893	.00466
15.00	19.077	4.5889	0.8253	4.6329	0.8332	0.0821	0.0148	0.890	.00574
16.00	18.211	5.1209	0.9210	5.1695	0.9298	0.0905	0.0163	0.9398	.00683
17.00	17.414	5.6777	1.0212	5.7311	1.0308	0.0993	0.0179	0.9314	.00795
18.00	16.692	6.2598	1.1259	6.3182	1.1364	0.1083	0.0195	0.9237	.00912
19.00	16.035	6.8665	1.2350	6.9300	1.2464	0.1177	0.0212	0.9165	.01060
20.00	15.434	7.4964	1.3483	7.5652	1.3606	0.1275	0.0229	0.9097	.01226
22.00	14.374	8.8288	1.5879	8.9080	1.6023	0.1478	0.0266	0.8779	.01694
24.00	13.466	1.0256	1.8446	1.0348	1.8612	0.1693	0.0305	0.8675	.02169
26.00	12.681	1.1774	2.1177	1.1879	2.1365	0.1920	0.0345	0.8781	.02486
28.00	11.993	1.3384	2.4072	1.3501	2.4263	0.2157	0.0388	0.8700	.02637
30.00	11.385	1.5083	2.7127	1.5214	2.7363	0.2405	0.0433	0.8628	.02794
32.00	10.842	1.6869	3.0339	1.7014	3.0601	0.2664	0.0479	0.8560	.02958
34.00	10.360	1.8741	3.3707	1.8902	3.3996	0.2933	0.0528	0.8501	.03127
36.00	9.9244	2.0698	3.7237	2.0875	3.7544	0.3212	0.0578	0.8447	.03302
38.00	9.5298	2.2740	4.0899	2.2932	4.1245	0.3501	0.0630	0.8398	.03481
40.00	9.1700	2.4863	4.4717	2.5072	4.5094	0.3799	0.0683	0.8352	.03666
45.00	8.3947	3.0524	5.4899	3.0778	5.5356	0.4585	0.0825	0.8251	.04147
50.00	7.7581	3.6678	6.5967	3.6980	6.6510	0.5426	0.0976	0.8168	.04652
55.00	7.2254	4.3309	7.7894	4.3663	7.8530	0.6321	0.1137	0.8096	.05181
60.00	6.7728	5.0407	9.0660	5.0815	9.1394	0.7268	0.1307	0.8035	.05737
65.00	6.3831	5.7957	1.0424	5.8424	1.0508	0.8264	0.1486	0.7981	.06316
70.00	6.0440	6.5950	1.1862	6.6478	1.1956	0.9308	0.1674	0.7935	.06916
75.00	5.7460	7.4374	1.3377	7.4966	1.3483	1.0398	0.1870	0.7892	.07535
80.00	5.4819	8.3219	1.4967	8.3878	1.5086	1.1533	0.2074	0.7855	.08171
90.00	5.0346	10.213	1.8369	10.294	1.8514	1.3932	0.2506	0.7792	.09486

## SILVER CHLORIDE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
100.00	4.6698	12.262	2.2055	12.358	2.2227	.16492	.02966	1.335	.10846
110.00	4.3664	14.462	2.6011	14.574	2.6213	.19206	.03454	1.318	.12252
120.00	4.1117	16.866	3.0227	16.936	3.0460	.22060	.03968	1.303	.13705
130.00	3.8916	19.268	3.4691	19.437	3.4958	.25050	.04505	1.289	.15199
140.00	3.7011	21.906	3.9399	22.074	3.9701	.28170	.05066	1.276	.16725
150.00	3.5344	24.351	4.4336	24.839	4.4674	.31412	.05650	1.265	.18276
160.00	3.3873	27.520	4.9497	27.730	4.9873	.34771	.06254	1.254	.19851
170.00	3.2565	30.511	5.4875	30.742	5.5292	.38240	.06876	1.244	.21450
180.00	3.1395	33.616	6.0460	33.870	6.0918	.41814	.07521	1.235	.23070
190.00	3.0342	36.833	6.6247	37.112	6.6747	.45489	.08181	1.226	.24703
200.00	2.9399	40.157	7.2225	40.460	7.2770	.49257	.08859	1.217	.26346
210.00	2.8533	43.586	7.8391	43.914	7.8981	.53113	.09553	1.209	.27992
220.00	2.7742	47.116	8.4741	47.470	8.5378	.57056	.10262	1.202	.29637
230.00	2.7017	50.739	9.1257	51.120	9.1942	.61093	.10986	1.195	.31276
240.00	2.6351	54.461	9.7952	54.869	9.8686	.65186	.11724	1.188	.32907
250.00	2.5736	58.275	10.481	58.711	10.560	.69369	.12477	1.182	.34527
260.00	2.5168	62.176	11.183	62.641	11.266	.73623	.13242	1.175	.36140
270.00	2.4641	66.164	11.900	66.650	11.989	.77946	.14019	1.169	.37751
280.00	2.4150	70.236	12.632	70.760	12.727	.82335	.14809	1.164	.39358
290.00	2.3693	74.387	13.379	74.942	13.479	.86788	.15609	1.158	.40958
300.00	2.3266	78.617	14.140	79.203	14.245	.91302	.16421	1.153	.42549
310.00	2.2866	82.922	14.914	83.539	15.025	.95874	.17244	1.148	.44127
320.00	2.2491	87.300	15.702	87.950	15.818	1.0050	.18076	1.143	.45689
330.00	2.2139	91.751	16.502	92.432	16.625	1.0518	.18918	1.138	.47233
340.00	2.1807	96.270	17.315	96.985	17.443	1.0992	.19769	1.133	.48758
350.00	2.1495	100.85	18.138	101.60	18.273	1.1470	.20629	1.129	.50261
360.00	2.1200	105.150	18.975	106.28	19.115	1.1953	.21498	1.125	.51743
370.00	2.0921	110.21	19.822	111.03	19.969	1.2441	.22375	1.120	.53203
380.00	2.0657	114.99	20.681	115.84	20.834	1.2932	.23260	1.116	.54638
390.00	2.0406	119.62	21.551	120.71	21.710	1.3429	.24153	1.113	.56049
400.00	2.0169	124.72	22.431	125.64	22.597	1.3929	.25052	1.109	.57434
410.00	1.9944	129.67	23.321	130.62	23.494	1.4433	.25959	1.105	.58793
420.00	1.9729	134.67	24.222	135.67	24.400	1.4941	.26873	1.101	.60124
430.00	1.9525	139.73	25.131	140.76	25.317	1.5453	.27793	1.098	.61427
440.00	1.9330	144.84	26.051	145.91	26.243	1.5968	.28720	1.094	.62702
450.00	1.9145	150.00	26.979	151.11	27.178	1.6487	.29652	1.091	.63948
460.00	1.8968	155.21	27.916	156.36	28.122	1.7008	.30591	1.088	.65165
470.00	1.8798	160.47	28.862	161.65	29.074	1.7533	.31535	1.085	.66353
480.00	1.8636	165.77	29.816	166.95	30.035	1.8061	.32484	1.082	.67511
490.00	1.8482	171.12	30.778	172.38	31.004	1.8592	.33439	1.079	.68641

# SILVER CHLORIDE

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2 CM	PROTON PATH LENGTH GM/CM2 CM	PATH LENGTH STRAGGLING GM/CM2 CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
500.00	1.8333	10.193	177.82	31.981	1.9126	.69741
510.00	1.8191	10.114	183.29	32.966	1.9662	.70812
520.00	1.8055	10.039	188.81	33.959	2.0201	.71854
530.00	1.7924	9.9659	194.37	34.958	2.0743	.72868
540.00	1.7799	9.8961	199.97	35.965	2.1287	.73852
550.00	1.7678	9.8291	205.60	36.979	2.1834	.74809
560.00	1.7562	9.7646	211.28	38.000	2.2383	.75738
570.00	1.7451	9.7027	216.99	39.027	2.2934	.76639
580.00	1.7344	9.6431	222.74	40.061	2.3487	.77513
590.00	1.7240	9.5857	228.52	41.101	2.4042	.78361
600.00	1.7141	9.5304	234.34	42.148	2.4599	.79182
620.00	1.6953	9.4258	246.07	44.258	2.5720	.80747
640.00	1.6778	9.3285	257.93	46.391	2.6848	.82213
660.00	1.6615	9.2379	269.91	48.545	2.7983	.83583
680.00	1.6463	9.1533	279.97	50.720	2.9125	.84862
700.00	1.6321	9.0743	292.08	52.915	3.0272	.86054
720.00	1.6189	9.0004	306.51	55.128	3.1426	.87164
740.00	1.6063	8.9312	318.92	57.361	3.2585	.88195
760.00	1.5947	8.8663	331.42	59.608	3.3749	.89153
780.00	1.5837	8.8053	344.01	61.872	3.4919	.90040
800.00	1.5734	8.7481	356.71	64.156	3.6093	.90862
820.00	1.5637	8.6942	369.46	66.450	3.7271	.91623
840.00	1.5546	8.6435	379.55	68.758	3.8454	.92325
860.00	1.5460	8.5957	392.37	71.078	3.9641	.92974
880.00	1.5379	8.5507	408.17	73.412	4.0831	.93572
900.00	1.5303	8.5082	418.21	75.758	4.2026	.94123
920.00	1.5230	8.4681	431.23	78.116	4.3224	.94630
940.00	1.5162	8.4303	444.33	80.489	4.4425	.95097
960.00	1.5098	8.3945	457.49	82.872	4.5629	.95525
1000.00	1.4979	8.3286	484.16	87.078	4.8047	.96276

THE ELECTRON DENSITY OF SILVER CHLORIDE IS 2.690E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.056 BEV, AND THE MINIMUM ENERGY LOSS IS 1.4027 MEV/GH/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 355.94 ELECTRON VOLTS



# STEEL (STAINLESS)

PROTON ENERGY MEV	ELEMENT	ATOMIC NUMBER	ATOMS/MOLECULE	PERCENT BY WEIGHT	ATOMIC WEIGHT	ADJUSTED IONIZATION POTENTIAL	PATH LENGTH MH	PROTON PATH LENGTH MH	ENERGY LOSS MEV/CM	PROTON RANGE MH	MG/CM2	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	FE	26	1.0000	72.9000	55.847	273.0	.02052	.47406	336.96	.00058	.46353	2.220	0.
.15	CR	24	.26520	18.0000	51.996	244.4	.02429	.62658	318.85	.00078	.61534	1.793	0.
.20	NI	28	.11744	9.0000	58.710	312.0	.02793	.78838	299.40	.00098	.77570	1.608	0.
.30	C	6	.00638	.1000	12.011	75.10	.03533	1.1428	265.59	.00142	1.1265	1.431	0.
.40							.04392	1.5476	229.24	.00193	1.5270	1.332	0.
.50							.05515	2.0163	199.76	.00254	1.9909	1.262	0.
.60							.06820	2.5425	181.46	.00317	2.5117	1.210	0.
.70							.08253	3.1213	164.20	.00394	3.0849	1.169	0.
.80							.09827	3.7566	151.92	.00468	3.7139	1.135	0.
.90							.11442	4.4341	143.13	.00553	4.3851	1.106	0.
1.00							.13100	5.1556	134.34	.00643	5.0998	1.081	0.
1.20							.16628	6.7320	120.28	.00840	6.6620	1.040	0.
1.40							.20394	8.4773	109.49	.01058	8.3920	1.007	0.
1.60							.24375	10.384	100.82	.01297	10.282	.9789	0.
1.80							.28558	12.443	93.659	.01554	12.324	.9551	0.
2.00							.32932	14.653	87.635	.01831	14.516	.9344	0.
2.20							.37488	17.005	82.502	.02125	16.850	.9162	0.
2.40							.42214	19.499	78.066	.02437	19.323	.8998	0.
2.60							.47110	22.129	74.135	.02766	21.933	.8853	0.
2.80							.52174	24.894	70.642	.03112	24.677	.8720	0.
3.00							.57410	27.791	67.512	.03474	27.552	.8598	0.
3.20							.62819	30.818	64.685	.03853	30.556	.8487	0.
3.40							.68403	33.974	62.116	.04248	33.689	.8384	0.
3.60							.74187	37.257	59.769	.04659	58.948	.8288	.00001
3.80							.80166	40.665	57.616	.05086	56.932	.8199	.00001
4.00							.86334	44.199	55.631	.05528	54.840	.8116	.00001
4.20							.92689	47.856	53.796	.05985	52.722	.8038	.00002
4.40							.99225	51.634	52.093	.06459	51.223	.7966	.00002
4.60							1.0594	55.534	50.506	.06943	50.051	.7897	.00002
4.80							1.1262	59.553	49.029	.07451	48.80	.7831	.00003

DENSITY = 7.9300 GN/CM3

## STEEL (STAINLESS)

PROCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GM/CM2	MEV/CM	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
5.00	47.648	377.85	.06320	.00797	.06369	.00803	.00120	.00015	.7770	.00004
5.50	44.554	353.31	.07398	.00933	.07455	.00940	.00138	.00017	.7630	.00006
6.00	41.885	332.15	.08548	.01078	.08613	.01086	.00158	.00020	.7506	.00009
6.50	39.555	313.67	.09769	.01232	.09842	.01241	.00178	.00022	.7396	.00012
7.00	37.494	297.33	.11060	.01395	.11141	.01405	.00199	.00025	.7297	.00016
7.50	35.664	282.81	.12419	.01560	.12501	.01577	.00221	.00028	.7207	.00021
8.00	34.030	269.86	.13845	.01746	.13945	.01758	.00244	.00031	.7125	.00027
8.50	32.549	258.11	.15339	.01934	.15448	.01948	.00268	.00034	.7051	.00034
9.00	31.225	247.61	.16898	.02131	.17017	.02146	.00293	.00037	.6983	.00041
9.50	30.016	238.02	.18520	.02335	.18649	.02352	.00318	.00040	.6919	.00049
10.00	28.906	229.23	.20208	.02548	.20347	.02566	.00344	.00043	.6860	.00058
11.00	26.947	213.69	.23771	.02998	.23933	.03018	.00399	.00050	.6754	.00077
12.00	25.263	200.34	.27583	.03478	.27768	.03502	.00457	.00058	.6662	.00105
13.00	23.799	188.73	.31638	.03990	.31848	.04016	.00518	.00065	.6579	.00144
14.00	22.513	178.53	.35935	.04532	.36170	.04561	.00582	.00073	.6506	.00194
15.00	21.374	169.50	.40469	.05103	.40731	.05136	.00648	.00082	.6439	.00259
16.00	20.358	161.44	.45236	.05704	.45527	.05741	.00718	.00091	.6379	.00346
17.00	19.444	154.19	.50234	.06335	.50554	.06375	.00790	.00100	.6324	.00466
18.00	18.619	147.65	.55461	.06994	.55811	.07038	.00865	.00109	.6274	.01094
19.00	17.869	141.70	.60914	.07681	.61296	.07730	.00943	.00119	.6228	.01344
20.00	17.184	136.27	.66590	.08397	.67004	.08449	.01023	.00129	.6185	.01596
22.00	15.978	126.71	.78600	.09912	.79085	.09973	.01192	.00150	.6108	.01850
24.00	14.950	118.55	.91476	.11535	.92032	.11606	.01370	.00173	.6041	.02364
26.00	14.062	111.51	1.0520	.13266	1.0583	.13346	.01559	.00197	.5983	.02885
28.00	13.285	105.35	1.1976	.15102	1.2047	.15192	.01757	.00222	.5930	.03227
30.00	12.601	99.926	1.3514	.17041	1.3594	.17142	.01965	.00248	.5883	.03385
32.00	11.993	95.104	1.5132	.19082	1.5221	.19194	.02181	.00275	.5841	.03550
34.00	11.449	90.787	1.6830	.21224	1.6929	.21348	.02407	.00304	.5802	.03721
36.00	10.958	86.895	1.8607	.23434	1.8715	.23600	.02642	.00333	.5767	.03899
38.00	10.514	83.373	2.0461	.25802	2.0579	.25950	.02885	.00364	.5735	.04082
40.00	10.109	80.167	2.2391	.28235	2.2519	.28397	.03137	.00396	.5705	.04271
45.00	9.2403	73.275	2.7543	.34732	2.7699	.34929	.03802	.00479	.5640	.04466
50.00	8.5287	67.632	3.3151	.41804	3.3337	.42039	.04517	.00570	.5505	.04973
55.00	7.9346	62.921	3.9201	.49434	3.9420	.49710	.05280	.00666	.5339	.05507
60.00	7.4306	58.925	4.5683	.5760	4.5936	.57927	.06099	.00768	.5199	.06086
65.00	6.9974	55.489	5.2585	.66314	5.2874	.66676	.06943	.00875	.5063	.06656
70.00	6.6223	52.515	5.9897	.75532	6.0224	.75944	.07839	.00988	.4932	.07267
75.00	6.2918	49.894	6.7606	.85254	6.7974	.85717	.08776	.01107	.4805	.07899
80.00	5.9987	47.569	7.5987	.95466	7.6314	.95983	.09753	.01230	.4681	.08550
90.00	5.5035	43.642	9.3045	1.1733	9.3544	1.1796	.11922	.01491	.4538	.09218

STEEL (STAINLESS)

PROTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM <sup>2</sup>	PROTON PATH LENGTH GM/CM <sup>2</sup>	PROTON PATH LENGTH CM	PATH STRAGGLING GM/CM <sup>2</sup>	PATH STRAGGLING CM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	5.1001	11.184	11.243	1.4178	1.4038	.01770	1.249	.5302	.12009
110.00	4.7650	13.204	13.274	1.6738	1.6391	.02067	1.235	.5273	.13468
120.00	4.4820	15.358	15.439	1.9469	1.8874	.02380	1.222	.5247	.14978
130.00	4.2397	17.642	17.735	2.2364	2.1479	.02709	1.211	.5225	.16530
140.00	4.0300	20.050	20.155	2.5416	2.4201	.03052	1.201	.5205	.18115
150.00	3.8466	22.578	22.692	2.8620	2.7034	.03409	1.191	.5188	.19725
160.00	3.6849	25.221	25.352	3.1970	2.9971	.03779	1.182	.5173	.21359
170.00	3.5412	27.977	28.122	3.5462	3.3008	.04162	1.174	.5159	.23019
180.00	3.4128	30.840	30.999	3.9091	3.6140	.04557	1.166	.5146	.24697
190.00	3.2972	33.807	33.981	4.2851	3.9362	.04964	1.158	.5135	.26389
200.00	3.1926	36.874	37.064	4.6739	4.2671	.05381	1.151	.5125	.28089
210.00	3.0977	40.039	40.245	5.0750	4.6062	.05809	1.145	.5115	.29794
220.00	3.0110	43.297	43.519	5.4879	4.9532	.06246	1.138	.5106	.31502
230.00	2.9316	46.647	46.886	5.9124	5.3076	.06693	1.132	.5090	.33207
240.00	2.8587	50.084	50.340	6.3481	5.6693	.07149	1.126	.5091	.34907
250.00	2.7914	53.607	53.881	6.7946	6.0378	.07614	1.121	.5084	.36598
260.00	2.7292	57.212	57.504	7.2515	6.4129	.08087	1.115	.5077	.38279
270.00	2.6714	60.898	61.208	7.7186	6.7943	.08568	1.110	.5071	.39949
280.00	2.6178	64.661	64.990	8.1955	7.1017	.09056	1.105	.5065	.41605
290.00	2.5677	68.499	68.847	8.6819	7.5749	.09552	1.100	.5059	.43245
300.00	2.5210	72.410	72.778	9.1776	7.9736	.10055	1.096	.5054	.44867
310.00	2.4773	76.393	76.780	9.6822	8.3777	.10565	1.091	.5049	.46468
320.00	2.4362	80.443	80.851	10.196	8.7869	.11081	1.087	.5044	.48048
330.00	2.3977	84.561	84.989	10.717	9.2009	.11603	1.083	.5039	.49605
340.00	2.3614	88.743	89.192	11.247	9.6197	.12131	1.079	.5034	.51138
350.00	2.3273	92.988	93.458	11.785	1.0043	.12665	1.075	.5030	.52644
360.00	2.2950	97.294	97.785	12.331	1.0471	.13204	1.071	.5026	.54127
370.00	2.2645	101.66	102.17	12.884	1.0903	.13749	1.067	.5021	.55588
380.00	2.2356	106.08	106.62	13.445	1.1339	.14298	1.063	.5017	.57026
390.00	2.2083	110.56	111.12	14.012	1.1778	.14853	1.060	.5013	.58440
400.00	2.1823	115.09	115.67	14.587	1.2222	.15412	1.057	.5009	.59830
410.00	2.1577	119.68	120.28	15.168	1.2669	.15976	1.053	.5006	.61191
420.00	2.1342	124.32	124.94	15.756	1.3120	.16544	1.050	.5002	.62520
430.00	2.1119	129.00	129.65	16.350	1.3574	.17117	1.047	.4998	.63818
440.00	2.0906	133.74	134.41	16.950	1.4031	.17693	1.044	.4995	.65084
450.00	2.0704	138.52	139.22	17.556	1.4491	.18274	1.041	.4991	.66319
460.00	2.0510	143.35	144.07	18.168	1.4954	.18858	1.038	.4987	.67521
470.00	2.0325	148.23	148.97	18.785	1.5420	.19446	1.035	.4984	.68691
480.00	2.0149	153.14	153.91	19.409	1.5889	.20037	1.032	.4980	.69829
490.00	1.9980	158.10	158.89	20.037	1.6361	.20632	1.030	.4977	.70935

# STEEL (STAINLESS)

PROTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
		GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
500.00	1.9818	163.11	20,568	163.92	20.671	1.6835	.21230	.4974	.72010
510.00	1.9663	168.15	21,204	168.99	21.310	1.7312	.21831	.4970	.73053
520.00	1.9514	173.23	21,845	174.09	21.954	1.7792	.22436	.4967	.74066
530.00	1.9371	178.35	22,490	179.24	22.602	1.8273	.23043	.4963	.75048
540.00	1.9234	183.50	23,140	184.42	23.255	1.8757	.23653	.4960	.75999
550.00	1.9103	188.69	23,795	189.63	23.913	1.9243	.24266	.4957	.76921
560.00	1.8977	193.92	24,454	194.89	24.576	1.9732	.24882	.4953	.77814
570.00	1.8855	199.18	25,117	200.17	25.242	2.0222	.25501	.4950	.78677
580.00	1.8738	204.48	25,785	205.49	25.913	2.0714	.26121	.4947	.79513
590.00	1.8626	209.80	26,457	210.84	26.588	2.1209	.26745	.4943	.80321
600.00	1.8517	215.16	27,133	216.23	27.267	2.1705	.27371	.4940	.81101
620.00	1.8312	225.97	28,496	227.09	28.637	2.2703	.28629	.4934	.82584
640.00	1.8121	236.90	29,874	238.07	30.022	2.3707	.29896	.4927	.83965
660.00	1.7944	247.94	31,266	249.16	31.420	2.4719	.31171	.4920	.85250
680.00	1.7778	259.08	32,671	260.36	32.832	2.5736	.32454	.4914	.86443
700.00	1.7624	271.33	34,089	271.66	34.257	2.6759	.33744	.4907	.87550
720.00	1.7479	283.67	35,519	283.06	35.694	2.7788	.35041	.4901	.88375
740.00	1.7343	295.10	36,961	294.54	37.143	2.8821	.36345	.4894	.89524
760.00	1.7216	306.62	38,414	306.12	38.603	2.9860	.37655	.4887	.90400
780.00	1.7097	318.23	39,877	317.78	40.073	3.0903	.38970	.4881	.91210
800.00	1.6985	329.91	41,350	329.52	41.553	3.1951	.40291	.4874	.91956
820.00	1.6880	339.67	42,833	341.33	43.043	3.3003	.41618	.4867	.92643
840.00	1.6781	351.50	44,325	353.21	44.541	3.4059	.42949	.4860	.93276
860.00	1.6687	363.40	45,825	365.17	46.049	3.5118	.44285	.4853	.93857
880.00	1.6599	375.36	47,334	377.19	47.565	3.6182	.45626	.4847	.94392
900.00	1.6516	387.39	48,851	389.27	49.089	3.7248	.46971	.4840	.94882
920.00	1.6438	399.48	50,376	401.42	50.620	3.8318	.48321	.4832	.95332
940.00	1.6364	411.63	51,908	413.63	52.160	3.9392	.49674	.4824	.95745
960.00	1.6294	423.85	53,449	425.91	53.708	4.0468	.51031	.4815	.96123
1000.00	1.6166	448.58	56,568	450.74	56.840	4.2629	.53756	.4792	.96784

THE ELECTRON DENSITY OF STEEL (STAINLESS) IS 2.807E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.101 BEV, AND THE MINIMUM ENERGY LOSS IS 1.5139 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 270.60 ELECTRON VOLTS

TEFLON

ATOMIC NUMBER 6  
ELEMENT C  
F  
ATOMS/MOLECULE 2  
4  
PERCENT BY WEIGHT 24.0185  
75.9815  
ADJUSTED IONIZATION POTENTIAL 77.30  
120.7

DENSITY = 2.2000 GM/CM3

PROTON ENERGY MEV	ENERGY LOSS GM/CH2	HEV/CH	PROTON RANGE CM	PROTON PATH LENGTH GM/CH2	PROTON PATH LENGTH CM	HG/CH2	PATH LENGTH STRAGGLING CM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
.10	653.28	1437.2	.19311	.00088	.19488	.00089	.00700	.00003	3.594	.9064
.15	580.42	1276.9	.27414	.00125	.27603	.00125	.00876	.00004	3.173	.6843
.20	518.60	1140.9	.36498	.00165	.36712	.00167	.01066	.00005	2.904	.5824
.30	423.14	930.91	.57837	.00263	.58119	.00264	.01505	.00007	2.589	.4851
.40	357.65	786.83	.83539	.00380	.83905	.00381	.02043	.00009	2.435	.4361
.50	313.78	690.31	1.1337	.00515	1.1383	.00517	.02682	.00012	2.356	.4058
.60	284.11	625.05	1.4681	.00667	1.4738	.00670	.03376	.00015	2.291	.3846
.70	262.13	576.68	1.8336	.00833	1.8404	.00837	.04096	.00019	2.226	.3687
.80	242.24	532.93	2.2292	.01013	2.2371	.01017	.04844	.00022	2.165	.3557
.90	221.77	487.90	2.6592	.01209	2.6684	.01213	.05653	.00026	2.118	.3448
1.00	201.29	442.83	3.1310	.01423	3.1415	.01428	.06566	.00030	2.090	.3355
1.20	177.60	390.71	4.1880	.01904	4.2015	.01910	.08612	.00039	2.050	.3207
1.40	159.66	351.25	5.3745	.02443	5.3912	.02451	.10823	.00049	2.008	.3096
1.60	145.45	320.00	6.6856	.03039	6.7058	.03048	.13192	.00060	1.967	.3007
1.80	133.86	294.48	8.1172	.03690	8.1411	.03700	.15715	.00071	1.930	.2934
2.00	124.18	273.20	9.6554	.04393	9.6933	.04406	.18387	.00084	1.897	.2873
2.20	115.97	255.14	11.328	.05149	11.361	.05164	.21206	.00096	1.867	.2820
2.40	108.91	239.59	13.105	.05957	13.142	.05973	.24169	.00110	1.839	.2773
2.60	102.75	226.86	14.992	.06815	15.033	.06833	.27271	.00124	1.814	.2732
2.80	97.340	214.15	16.988	.07722	17.034	.07743	.30510	.00139	1.791	.2696
3.00	92.534	203.57	19.091	.08678	19.142	.08701	.33883	.00154	1.770	.2662
3.20	88.234	194.11	21.300	.09662	21.356	.09707	.37389	.00170	1.751	.2632
3.40	84.360	185.59	23.613	.10733	23.675	.10761	.41025	.00186	1.733	.2604
3.60	80.851	177.87	26.030	.11832	26.098	.11863	.44789	.00204	1.716	.2579
3.80	77.653	170.84	28.549	.12977	28.622	.13010	.48680	.00221	1.701	.2555
4.00	74.726	164.40	31.169	.14168	31.248	.14204	.52696	.00240	1.686	.2534
4.20	71.997	158.39	33.890	.15405	33.976	.15444	.56839	.00258	1.673	.2513
4.40	69.520	152.94	36.712	.16687	36.804	.16729	.61104	.00278	1.660	.2494
4.60	67.225	147.90	39.630	.18014	39.728	.18058	.65491	.00298	1.648	.2476
4.80	65.093	143.20	42.649	.19386	42.754	.19434	.69997	.00318	1.637	.2460
5.00	63.011	139.57	45.761	.20811	45.876	.20861	.74691	.00338	1.626	.2444
5.20	61.000	136.00	48.961	.22291	49.086	.22336	.79581	.00358	1.615	.2428
5.40	59.055	132.57	52.251	.23816	52.341	.23861	.84561	.00378	1.604	.2412
5.60	57.172	129.26	55.631	.25386	55.721	.25411	.89631	.00398	1.593	.2396
5.80	55.347	126.06	59.101	.26991	59.196	.27016	.94791	.00418	1.582	.2380
6.00	53.578	122.96	62.651	.28631	62.746	.28656	.99941	.00438	1.571	.2364
6.20	51.861	119.96	66.281	.30306	66.396	.30331	.10506	.00458	1.560	.2348
6.40	50.194	117.06	69.991	.32016	70.106	.32041	.11076	.00478	1.549	.2332
6.60	48.577	114.26	73.781	.33761	73.896	.33786	.11646	.00498	1.538	.2316
6.80	46.999	111.56	77.651	.35541	77.766	.35566	.12216	.00518	1.527	.2300
7.00	45.461	108.96	81.591	.37356	81.706	.37381	.12786	.00538	1.516	.2284
7.20	43.962	106.46	85.601	.39196	85.716	.39221	.13356	.00558	1.505	.2268
7.40	42.503	104.06	89.681	.41061	89.796	.41086	.13926	.00578	1.494	.2252
7.60	41.084	101.76	93.831	.42951	93.946	.42976	.14496	.00598	1.483	.2236
7.80	39.705	99.56	98.051	.44866	98.166	.44891	.15066	.00618	1.472	.2220
8.00	38.366	97.46	102.341	.46796	102.456	.46821	.15636	.00638	1.461	.2204
8.20	37.067	95.46	106.691	.48741	106.806	.48766	.16206	.00658	1.450	.2188
8.40	35.808	93.56	111.101	.50691	111.216	.50716	.16776	.00678	1.439	.2172
8.60	34.589	91.76	115.571	.52656	115.686	.52681	.17346	.00698	1.428	.2156
8.80	33.410	89.96	120.101	.54626	120.216	.54651	.17916	.00718	1.417	.2140
9.00	32.271	88.26	124.681	.56601	124.796	.56626	.18486	.00738	1.406	.2124
9.20	31.172	86.66	129.311	.58581	129.426	.58606	.19056	.00758	1.395	.2108
9.40	30.113	85.16	133.981	.60566	134.096	.60591	.19626	.00778	1.384	.2092
9.60	29.094	83.76	138.691	.62556	138.806	.62581	.20196	.00798	1.373	.2076
9.80	28.115	82.46	143.441	.64541	143.556	.64566	.20766	.00818	1.362	.2060
10.00	27.176	81.26	148.231	.66526	148.346	.66551	.21336	.00838	1.351	.2044

TEFLON

PRCTON ENERGY MEV	ENERGY LOSS MEV/CM	PROTON RANGE GM/CM2	PROTON PATH LENGTH GM/CM2	GM/CM2	CM	PATH LENGTH STRAGGLING CM	PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	63.106	138.83	0.4576	0.02080	0.0075	0.0034	1.627	.2444	.00045
5.50	58.630	129.10	0.5397	0.02459	0.0087	0.0039	1.603	.2408	.00057
6.00	54.890	120.76	0.6291	0.02860	0.0099	0.0045	1.581	.2376	.00122
6.50	51.604	113.53	0.7214	0.03279	0.0113	0.0051	1.563	.2348	.00211
7.00	48.725	107.20	0.8210	0.03732	0.0127	0.0058	1.546	.2323	.00301
7.50	46.180	101.60	0.9262	0.04210	0.0142	0.0065	1.530	.2300	.00319
8.00	43.912	96.607	1.0370	0.04714	0.0158	0.0072	1.517	.2279	.00761
8.50	41.877	92.130	1.1534	0.05243	0.0174	0.0079	1.504	.2260	.01003
9.00	40.041	88.089	1.2753	0.05797	0.0191	0.0087	1.492	.2243	.01245
9.50	38.348	84.366	1.4026	0.06376	0.0208	0.0095	1.481	.2227	.01487
10.00	36.832	81.030	1.5354	0.06979	0.0226	0.0103	1.472	.2212	.01729
11.00	34.163	75.160	1.8171	0.08259	0.0265	0.0120	1.454	.2185	.02212
12.00	31.889	70.156	2.1196	0.09634	0.0305	0.0139	1.438	.2162	.02697
13.00	29.925	65.835	2.4429	0.11104	0.0349	0.0158	1.424	.2141	.03181
14.00	28.211	62.064	2.7865	0.12666	0.0394	0.0179	1.411	.2122	.03667
15.00	26.701	58.741	3.1503	0.14319	0.0442	0.0201	1.400	.2105	.04153
16.00	25.359	55.790	3.5339	0.16063	0.0492	0.0224	1.389	.2090	.04640
17.00	24.159	53.150	3.9373	0.17897	0.0544	0.0247	1.380	.2076	.05127
18.00	23.079	50.773	4.3602	0.19819	0.0599	0.0272	1.371	.2064	.05616
19.00	22.101	48.621	4.8022	0.21828	0.0656	0.0298	1.362	.2052	.06105
20.00	21.210	46.663	5.2633	0.23924	0.0715	0.0325	1.355	.2041	.06596
22.00	19.650	43.230	6.2419	0.28372	0.0839	0.0381	1.341	.2021	.07578
24.00	18.325	40.316	7.2946	0.33157	0.0971	0.0441	1.329	.2004	.08563
26.00	17.186	37.810	8.4201	0.38273	0.1112	0.0505	1.318	.1989	.09162
28.00	16.195	35.629	9.6173	0.43715	0.1260	0.0573	1.308	.1976	.09363
30.00	15.325	33.714	1.0885	0.49477	0.1416	0.0644	1.298	.1963	.09571
32.00	14.554	32.018	1.2222	0.55556	0.1580	0.0718	1.290	.1952	.09767
34.00	13.866	30.504	1.3628	0.61945	0.1751	0.0796	1.282	.1942	.10009
36.00	13.247	29.144	1.5101	0.68643	0.1929	0.0877	1.275	.1933	.10237
38.00	12.689	27.916	1.6642	0.75644	0.2115	0.0961	1.268	.1925	.10471
40.00	12.182	26.800	1.8248	0.82944	0.2307	0.1049	1.262	.1917	.10710
45.00	11.096	24.411	2.2546	1.0248	0.2818	0.1281	1.248	.1900	.11324
50.00	10.211	22.465	2.7240	1.2382	0.3371	0.1532	1.235	.1885	.11959
55.00	9.4756	20.846	3.2315	1.4600	0.3963	0.1801	1.224	.1873	.12617
60.00	8.8538	19.478	3.7771	1.7169	0.4594	0.2088	1.214	.1862	.13304
65.00	8.3211	18.306	4.3589	1.9813	0.5261	0.2392	1.205	.1852	.14016
70.00	7.8592	17.290	4.9765	2.2662	0.5965	0.2711	1.196	.1843	.14751
75.00	7.4548	16.401	5.6288	2.5585	0.6702	0.3047	1.189	.1836	.15504
80.00	7.0977	15.615	6.3152	2.8706	0.7474	0.3397	1.181	.1829	.16273
90.00	6.4952	14.289	7.7873	3.5337	0.9113	0.4142	1.168	.1817	.17844

## TEFLON

PRCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	MEV/ GH/CM2	MEV/CH	GH/CM2	CM	GH/CM2	CM	GH/CM2	PERCENT		
100.00	6.0061	13.213	9.3872	4.2669	9.4042	4.2747	.10874	.04943	1.156	.19443
110.00	5.6009	12.322	11.110	5.0499	11.130	5.0590	.12750	.05796	1.146	.21074
120.00	5.2597	11.571	12.950	5.8865	12.974	5.8971	.14736	.06698	1.136	.22746
130.00	4.9682	10.930	14.904	6.7747	14.931	6.7868	.16825	.07648	1.127	.24446
140.00	4.7163	10.376	16.968	7.7126	16.998	7.7263	.19012	.08642	1.118	.26164
150.00	4.4964	9.8921	19.136	8.6983	19.170	8.7138	.21292	.09678	1.111	.27890
160.00	4.3028	9.4661	21.407	9.7303	21.445	9.7476	.23662	.10755	1.103	.29625
170.00	4.1309	9.0881	23.775	10.807	23.817	10.826	.26115	.11871	1.096	.31370
180.00	3.9775	8.7504	26.239	11.927	26.285	11.948	.28649	.13022	1.090	.33118
190.00	3.8395	8.4470	28.794	13.088	28.845	13.111	.31260	.14209	1.084	.34865
200.00	3.7149	8.1728	31.438	14.290	31.493	14.315	.33944	.15429	1.078	.36603
210.00	3.6018	7.9239	34.168	15.531	34.227	15.558	.36699	.16681	1.072	.38332
220.00	3.4936	7.6970	36.980	16.809	37.045	16.839	.39520	.17964	1.067	.40052
230.00	3.4042	7.4893	39.874	18.124	39.943	18.156	.42405	.19275	1.062	.41760
240.00	3.3175	7.2984	42.845	19.475	42.919	19.509	.45352	.20615	1.057	.43450
250.00	3.2375	7.1225	45.891	20.860	45.971	20.896	.48357	.21981	1.052	.45120
260.00	3.1636	6.9599	49.011	22.278	49.096	22.316	.51419	.23372	1.047	.46770
270.00	3.0951	6.8092	52.202	23.728	52.292	23.769	.54535	.24789	1.043	.48403
280.00	3.0314	6.6690	55.461	25.210	55.557	25.253	.57703	.26228	1.039	.50013
290.00	2.9720	6.5385	58.783	26.722	58.889	26.768	.60920	.27691	1.034	.51601
300.00	2.9166	6.4166	62.179	28.263	62.286	28.312	.64185	.29175	1.030	.53163
310.00	2.8648	6.3025	65.613	29.833	65.746	29.884	.67496	.30580	1.027	.54701
320.00	2.8161	6.1955	69.148	31.431	69.267	31.495	.70852	.32205	1.023	.56217
330.00	2.7705	6.0950	72.722	33.055	72.847	33.112	.74249	.33750	1.019	.57708
340.00	2.7275	6.0005	76.354	34.706	76.485	34.766	.77688	.35313	1.016	.59174
350.00	2.6870	5.9114	80.042	36.383	80.179	36.445	.81166	.36894	1.012	.60612
360.00	2.6488	5.8274	83.784	38.004	83.928	38.149	.84681	.38492	1.009	.62027
370.00	2.6127	5.7479	87.579	39.609	87.729	39.877	.88234	.40106	1.006	.63422
380.00	2.5785	5.6727	91.426	41.157	91.582	41.628	.91821	.41737	1.003	.64795
390.00	2.5461	5.6014	95.323	43.328	95.485	43.402	.95442	.43383	.9995	.66145
400.00	2.5154	5.5338	99.268	45.122	99.437	45.199	.99096	.45044	.9966	.67470
410.00	2.4862	5.4696	103.26	46.936	103.44	47.015	1.0278	.46719	.9937	.68763
420.00	2.4584	5.4085	107.30	48.772	107.48	48.855	1.0650	.48408	.9908	.70017
430.00	2.4320	5.3504	111.38	50.628	111.57	50.714	1.1024	.50110	.9881	.71234
440.00	2.4068	5.2950	115.51	52.504	115.70	52.593	1.1402	.51825	.9854	.72412
450.00	2.3826	5.2422	119.68	54.399	119.88	54.491	1.1782	.53553	.9828	.73555
460.00	2.3599	5.1918	123.89	56.312	124.10	56.408	1.2164	.55293	.9802	.74656
470.00	2.3380	5.1436	128.14	58.244	128.35	58.343	1.2550	.57044	.9777	.75722
480.00	2.3171	5.0976	132.43	60.194	132.65	60.266	1.2938	.58807	.9753	.76752
490.00	2.2970	5.0535	136.75	62.161	136.99	62.266	1.3328	.60580	.9729	.77746

TEFLON

PRCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GH/CH2	MEV/CH	GM/CM2	CM	GM/CM2	CM	GM/CM2	CM		
300.00	2.2779	5.0113	141.12	64.145	141.36	64.254	1.3720	.62365	.9706	.78704
510.00	2.2595	4.9709	145.52	66.146	145.77	66.257	1.4115	.64259	.9683	.79629
520.00	2.2419	4.9321	149.96	68.162	150.21	68.277	1.4512	.65913	.9661	.80519
530.00	2.2250	4.8949	154.43	70.194	154.69	70.312	1.4911	.67777	.9639	.81375
540.00	2.2087	4.8592	158.93	72.241	159.20	72.363	1.5312	.69617	.9618	.82201
550.00	2.1931	4.8249	163.47	74.303	163.74	74.428	1.5715	.71532	.9597	.82994
560.00	2.1781	4.7919	168.03	76.380	168.32	76.508	1.6120	.73277	.9577	.83757
570.00	2.1637	4.7602	172.63	78.470	172.92	78.602	1.6527	.75122	.9557	.84490
580.00	2.1498	4.7296	177.26	80.574	177.56	80.709	1.6935	.76980	.9538	.85193
590.00	2.1365	4.7002	181.92	82.692	182.23	82.830	1.7346	.78815	.9519	.85869
600.00	2.1236	4.6719	186.61	84.822	186.92	84.964	1.7758	.80718	.9500	.86517
620.00	2.0992	4.6183	196.07	89.121	196.39	89.270	1.8587	.84487	.9464	.87734
640.00	2.0766	4.5685	205.63	93.469	205.97	93.625	1.9423	.88284	.9430	.88851
660.00	2.0554	4.5220	215.30	97.862	215.66	98.025	2.0264	.92108	.9396	.89875
680.00	2.0357	4.4786	225.06	102.30	225.43	102.47	2.1111	.95958	.9365	.90813
700.00	2.0173	4.4381	234.91	106.78	235.30	106.96	2.1963	.99831	.9334	.91670
720.00	2.0000	4.4001	244.86	111.30	245.26	111.48	2.2820	1.0373	.9304	.92453
740.00	1.9839	4.3645	254.88	115.85	255.30	116.05	2.3682	1.0765	.9276	.93167
760.00	1.9687	4.3311	264.99	120.45	265.42	120.65	2.4549	1.1158	.9249	.93817
780.00	1.9544	4.2993	275.17	125.08	275.62	125.28	2.5419	1.1554	.9223	.94409
800.00	1.9410	4.2703	285.42	129.76	285.89	129.95	2.6294	1.1952	.9197	.94947
820.00	1.9284	4.2425	295.74	134.43	296.23	134.65	2.7173	1.2351	.9173	.95435
840.00	1.9165	4.2163	306.13	139.15	306.63	139.38	2.8056	1.2753	.9150	.95878
860.00	1.9053	4.1917	316.58	143.90	317.10	144.14	2.8942	1.3153	.9127	.96280
880.00	1.8947	4.1684	327.10	148.68	327.63	148.92	2.9832	1.3560	.9105	.96645
900.00	1.8847	4.1464	337.67	153.49	338.22	153.74	3.0725	1.3966	.9084	.96974
920.00	1.8753	4.1256	348.30	158.32	348.86	158.57	3.1621	1.4373	.9064	.97273
940.00	1.8663	4.1060	358.99	163.18	359.57	163.44	3.2520	1.4782	.9044	.97543
960.00	1.8579	4.0874	369.73	168.06	370.33	168.33	3.3422	1.5192	.9025	.97787
1000.00	1.8423	4.0531	391.46	177.94	392.09	178.22	3.5235	1.6016	.8986	.98202

THE ELECTRON DENSITY OF TEFLON IS 2.891E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.246 BEV, AND THE MINIMUM ENERGY LOSS IS 1.7051 MEV/GH/CH2

THE EFFECTIVE IONIZATION POTENTIAL IS 107.98 ELECTRON VOLTS



# WATER

ATOMIC ELEMENT ATOMS/ MOLECULE PERCENT BY WEIGHT ADJUSTED IONIZATION POTENTIAL

H 1 2 11.1901 18.30

O 8 1 88.8099 98.50

DENSITY = 1.0000 GM/CM3

PROCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STRAGGLING		MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CH2	MEV/CH	MG/CH2	MM	MG/CH2	MM	MG/CH2	MM PERCENT		
.10	931.91	931.91	.11378	.00114	.11449	.00114	.00552	.00036 4.822	.6173	0.
.15	847.65	847.65	.16996	.00170	.17073	.00171	.00735	.00007 4.303	.4502	0.
.20	743.55	743.55	.23277	.00233	.23366	.00234	.00896	.00009 3.836	.3830	0.
.30	595.40	595.40	.38328	.00383	.38453	.00385	.01265	.00013 3.290	.3243	0.
.40	496.45	496.45	.56736	.00567	.56965	.00569	.01737	.00017 3.053	.2972	0.
.50	429.20	429.20	.78401	.00784	.78622	.00786	.02291	.00023 2.914	.2811	0.
.60	381.79	381.79	1.0308	.01031	1.0336	.01034	.02896	.00029 2.802	.2699	0.
.70	343.23	343.23	1.3063	.01306	1.3097	.01310	.03550	.00036 2.711	.2616	0.
.80	314.91	314.91	1.6098	.01610	1.6140	.01614	.04249	.00042 2.633	.2550	0.
.90	291.44	291.44	1.9389	.01939	1.9438	.01944	.04980	.00050 2.562	.2495	0.
1.00	267.95	267.95	2.2960	.02296	2.3017	.02302	.05764	.00058 2.504	.2448	0.
1.20	235.04	235.04	3.0930	.03093	3.1003	.03100	.07487	.00075 2.415	.2371	0.
1.40	210.12	210.12	3.9927	.03993	4.0020	.04002	.09367	.00094 2.341	.2311	0.
1.60	190.50	190.50	4.9921	.04992	5.0034	.05003	.11394	.00114 2.277	.2262	.00001
1.80	174.62	174.62	6.3878	.06388	6.41014	.06401	.13563	.00136 2.223	.2221	.00001
2.00	161.46	161.46	7.2775	.07278	7.2935	.07293	.15868	.00159 2.176	.2186	.00002
2.20	150.36	150.36	8.5592	.08559	8.5776	.08578	.18304	.00183 2.134	.2155	.00003
2.40	140.85	140.85	9.9317	.09932	9.9529	.09953	.20867	.00209 2.097	.2127	.00004
2.60	132.60	132.60	11.393	.11393	11.417	.11417	.23554	.00236 2.063	.2103	.00005
2.80	125.36	125.36	12.942	.12942	12.969	.12969	.26363	.00264 2.033	.2081	.00006
3.00	118.96	118.96	14.577	.14577	14.607	.14607	.29291	.00293 2.005	.2061	.00008
3.20	113.24	113.24	16.298	.16298	16.331	.16331	.32337	.00323 1.980	.2042	.00010
3.40	108.10	108.10	18.103	.18103	18.139	.18139	.35498	.00355 1.957	.2026	.00012
3.60	103.46	103.46	19.991	.19991	20.032	.20032	.38774	.00388 1.936	.2010	.00014
3.80	99.234	99.234	21.962	.21962	22.006	.22006	.42162	.00422 1.916	.1995	.00016
4.00	95.376	95.376	24.014	.24014	24.062	.24062	.45662	.00457 1.898	.1982	.00018
4.20	91.836	91.836	26.148	.26148	26.200	.26200	.49271	.00493 1.881	.1969	.00021
4.40	88.575	88.575	28.362	.28362	28.417	.28417	.52990	.00530 1.865	.1957	.00024
4.60	85.559	85.559	30.655	.30655	30.715	.30715	.56817	.00568 1.850	.1946	.00026
4.80	82.763	82.763	33.028	.33028	33.092	.33092	.60751	.00608 1.836	.1936	.00029

# WATER

PROCTON ENERGY MEV	ENERGY LOSS MEV/ GM/CM2	PROTON RANGE GM/CM2	PROTON RANGE CM	PROTON PATH LENGTH GM/CM2	PROTON PATH LENGTH CM	PATH LENGTH STRAGGLING GM/CM2	PATH LENGTH STRAGGLING CM	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
5.00	80.160	.03546	.03548	.03555	.03555	.00065	.00065	1.823	.00033
5.50	74.379	.04195	.04195	.04203	.04203	.00075	.00075	1.793	.00041
6.00	69.446	.04890	.04890	.04899	.04899	.00087	.00087	1.767	.00052
6.50	65.181	.05632	.05632	.05643	.05643	.00098	.00098	1.744	.00063
7.00	61.454	.06421	.06421	.06433	.06433	.00111	.00111	1.723	.00071
7.50	58.118	.07257	.07257	.07270	.07270	.00124	.00124	1.704	.00079
8.00	55.205	.08138	.08138	.08153	.08153	.00138	.00138	1.688	.00087
8.50	52.595	.09064	.09064	.09081	.09081	.00152	.00152	1.673	.00095
9.00	50.242	.10036	.10036	.10054	.10054	.00167	.00167	1.659	.00103
9.50	48.109	.11052	.11052	.11072	.11072	.00182	.00182	1.646	.00111
10.00	46.166	.12111	.12111	.12133	.12133	.00198	.00198	1.634	.00119
11.00	42.754	.14360	.14360	.14386	.14386	.00232	.00232	1.612	.00157
12.00	39.852	.16780	.16780	.16810	.16810	.00268	.00268	1.593	.00195
13.00	37.352	.19370	.19370	.19403	.19403	.00306	.00306	1.576	.00231
14.00	35.175	.22125	.22125	.22163	.22163	.00346	.00346	1.561	.00267
15.00	33.259	.25045	.25045	.25088	.25088	.00388	.00388	1.548	.00304
16.00	31.560	.28128	.28128	.28176	.28176	.00433	.00433	1.535	.00340
17.00	30.043	.31372	.31372	.31425	.31425	.00479	.00479	1.524	.00377
18.00	28.678	.34774	.34774	.34833	.34833	.00527	.00527	1.513	.00413
19.00	27.444	.38334	.38334	.38398	.38398	.00577	.00577	1.503	.00450
20.00	26.322	.42050	.42050	.42120	.42120	.00629	.00629	1.494	.00487
22.00	24.357	.49943	.49943	.50025	.50025	.00739	.00739	1.478	.00561
24.00	22.693	.58443	.58443	.58539	.58539	.00857	.00857	1.463	.00636
26.00	21.263	.67539	.67539	.67649	.67649	.00981	.00981	1.451	.00713
28.00	20.021	.77222	.77222	.77347	.77347	.01113	.01113	1.439	.00794
30.00	18.931	.87484	.87484	.87625	.87625	.01251	.01251	1.428	.00874
32.00	17.967	.98316	.98316	.98474	.98474	.01397	.01397	1.418	.00955
34.00	17.107	1.0971	1.0971	1.0988	1.0988	.01549	.01549	1.409	.01037
36.00	16.336	1.2166	1.2166	1.2185	1.2185	.01707	.01707	1.401	.01119
38.00	15.639	1.3416	1.3416	1.3437	1.3437	.01872	.01872	1.393	.01201
40.00	15.007	1.4719	1.4719	1.4743	1.4743	.02043	.02043	1.386	.01283
45.00	13.655	1.8212	1.8212	1.8240	1.8240	.02497	.02497	1.369	.01466
50.00	12.554	2.2029	2.2029	2.2063	2.2063	.02959	.02959	1.355	.01650
55.00	11.641	2.6162	2.6162	2.6203	2.6203	.03516	.03516	1.342	.01834
60.00	10.869	3.0604	3.0604	3.0651	3.0651	.04077	.04077	1.330	.02018
65.00	10.209	3.5347	3.5347	3.5401	3.5401	.04671	.04671	1.320	.02202
70.00	9.6367	4.0383	4.0383	4.0445	4.0445	.05298	.05298	1.310	.02386
75.00	9.1362	4.5706	4.5706	4.5776	4.5776	.05955	.05955	1.301	.02570
80.00	8.6944	5.1310	5.1310	5.1388	5.1388	.06643	.06643	1.293	.02754
90.00	7.9498	6.3337	6.3337	6.3432	6.3432	.08104	.08104	1.278	.03138

# WATER

PROTON ENERGY MEV	ENERGY LOSS MEV/CM GM/CM2	PROTON RANGE GM/CM2 CM	PROTON PATH LENGTH GM/CM2 CM	PATH LENGTH STRAGGLING GM/CM2 CH PERCENT	MULTIPLE SCATTERING PERCENT	PROBABILITY OF INELASTIC NUCLEAR INTERACTION
100.00	7.3459	7.6417	7.6532	.09674	.1499	.14881
110.00	6.8461	9.0509	9.0645	.11348	.1492	.16194
120.00	6.4254	10.558	10.573	.13120	.1487	.17546
130.00	6.0663	12.158	12.176	.14985	.1482	.18930
140.00	5.7561	13.849	13.869	.16938	.1477	.20336
150.00	5.4855	15.626	15.649	.18974	.1473	.21757
160.00	5.2473	17.488	17.514	.21090	.1469	.23192
170.00	5.0360	19.431	19.460	.23282	.1466	.24644
180.00	4.8474	21.453	21.485	.25547	.1463	.26106
190.00	4.6779	23.551	23.585	.27880	.1460	.27574
200.00	4.5248	25.722	25.759	.30279	.1457	.29043
210.00	4.3858	27.964	28.004	.32741	.1454	.30513
220.00	4.2592	30.275	30.319	.35264	.1452	.31984
230.00	4.1433	32.652	32.700	.37844	.1450	.33452
240.00	4.0368	35.094	35.145	.40479	.1447	.34914
250.00	3.9387	37.599	37.653	.43167	.1445	.36368
260.00	3.8475	40.165	40.223	.45906	.1443	.37817
270.00	3.7633	42.789	42.851	.48693	.1441	.39262
280.00	3.6851	45.471	45.536	.51527	.1439	.40701
290.00	3.6122	48.208	48.277	.54406	.1437	.42133
300.00	3.5441	51.000	51.073	.57328	.1436	.43556
310.00	3.4804	53.843	53.920	.60291	.1434	.44980
320.00	3.4207	56.737	56.819	.63294	.1432	.46396
330.00	3.3646	59.681	59.766	.66332	.1431	.47803
340.00	3.3118	62.673	62.762	.69413	.1429	.49198
350.00	3.2620	65.711	65.805	.72527	.1427	.50580
360.00	3.2151	68.794	68.893	.75675	.1426	.51954
370.00	3.1706	71.922	72.025	.78855	.1424	.53320
380.00	3.1286	75.093	75.200	.82067	.1423	.54679
390.00	3.0888	78.307	78.418	.85310	.1421	.56029
400.00	3.0510	81.560	81.676	.88583	.1420	.57366
410.00	3.0151	84.852	84.973	.91884	.1418	.58685
420.00	2.9809	88.184	88.309	.95212	.1417	.59978
430.00	2.9484	91.552	91.682	.98567	.1415	.61245
440.00	2.9174	94.957	95.092	1.0195	.1414	.62486
450.00	2.8878	98.398	98.537	1.0535	.1413	.63699
460.00	2.8596	101.87	102.02	1.0878	.1411	.64885
470.00	2.8326	105.38	105.53	1.1223	.1410	.66043
480.00	2.8068	108.92	109.08	1.1571	.1409	.67174
490.00	2.7821	112.50	112.66	1.1921	.1407	.68278

# WATER

PRCTON ENERGY MEV	ENERGY LOSS		PROTON RANGE		PROTON PATH LENGTH		PATH LENGTH STR'GLING		MULTIPLE SCATTERING		PROBABILITY OF INELASTIC NUCLEAR INTERACTION
	GM/CH2	MEV/CM	GM/CH2	CM	GM/CH2	CM	GM/CH2	PERCENT	PERCENT		
500.00	2.7585	2.7585	116.10	116.10	116.27	116.27	1.2272	1.056	.1406	.69354	
510.00	2.7358	2.7358	119.74	119.74	119.91	119.91	1.2626	1.053	.1404	.70403	
520.00	2.7140	2.7140	123.40	123.40	123.58	123.58	1.2982	1.051	.1403	.71427	
530.00	2.6932	2.6932	127.10	127.10	127.27	127.27	1.3340	1.048	.1402	.72425	
540.00	2.6731	2.6731	130.82	130.82	131.00	131.00	1.3699	1.046	.1400	.73398	
550.00	2.6538	2.6538	134.57	134.57	134.76	134.76	1.4060	1.043	.1399	.74346	
560.00	2.6353	2.6353	138.34	138.34	138.54	138.54	1.4424	1.041	.1398	.75268	
570.00	2.6175	2.6175	142.15	142.15	142.35	142.35	1.4788	1.039	.1396	.76166	
580.00	2.6003	2.6003	145.97	145.97	146.18	146.18	1.5155	1.037	.1395	.77039	
590.00	2.5838	2.5838	149.83	149.83	150.04	150.04	1.5523	1.035	.1394	.77887	
600.00	2.5679	2.5679	153.70	153.70	153.92	153.92	1.5892	1.033	.1392	.78710	
620.00	2.5377	2.5377	161.53	161.53	161.75	161.75	1.6636	1.028	.1390	.80287	
640.00	2.5096	2.5096	169.44	169.44	169.68	169.68	1.7385	1.025	.1387	.81774	
660.00	2.4834	2.4834	177.45	177.45	177.69	177.69	1.8140	1.021	.1385	.83172	
680.00	2.4589	2.4589	185.53	185.53	185.79	185.79	1.8899	1.017	.1382	.84483	
700.00	2.4360	2.4360	193.69	193.69	193.96	193.96	1.9664	1.014	.1379	.85712	
720.00	2.4145	2.4145	201.93	201.93	202.21	202.21	2.0433	1.011	.1377	.86861	
740.00	2.3943	2.3943	210.24	210.24	210.52	210.52	2.1207	1.007	.1374	.87933	
760.00	2.3754	2.3754	218.61	218.61	218.91	218.91	2.1984	1.004	.1372	.88931	
780.00	2.3576	2.3576	227.05	227.05	227.36	227.36	2.2766	1.001	.1369	.89856	
800.00	2.3408	2.3408	235.56	235.56	235.88	235.88	2.3551	.9985	.1366	.90710	
820.00	2.3250	2.3250	244.12	244.12	244.45	244.45	2.4340	.9957	.1364	.91499	
840.00	2.3101	2.3101	252.74	252.74	253.08	253.08	2.5133	.9931	.1361	.92227	
860.00	2.2960	2.2960	261.41	261.41	261.77	261.77	2.5929	.9905	.1359	.92897	
880.00	2.2827	2.2827	270.14	270.14	270.51	270.51	2.6727	.9880	.1356	.93514	
900.00	2.2701	2.2701	278.92	278.92	279.30	279.30	2.7529	.9857	.1353	.94081	
920.00	2.2582	2.2582	287.75	287.75	288.14	288.14	2.8334	.9834	.1351	.94602	
940.00	2.2469	2.2469	296.62	296.62	297.02	297.02	2.9142	.9811	.1348	.95081	
960.00	2.2362	2.2362	305.55	305.55	305.96	305.96	2.9952	.9789	.1345	.95520	
1000.00	2.2164	2.2164	323.61	323.61	324.04	324.04	3.1581	.9746	.1337	.96295	

THE ELECTRON DENSITY OF WATER IS 3.344E 23 ELECTRONS PER GRAM

THE PROTON KINETIC ENERGY FOR MINIMUM IONIZATION IS 2.310 BEV, AND THE MINIMUM ENERGY LOSS IS 2.0307 MEV/GM/CM2

THE EFFECTIVE IONIZATION POTENTIAL IS 70.35 ELECTRON VOLTS

# REFERENCES

1. Rich, M., and R. Madey, "Range Energy Tables," UCRL-2301, University of California Radiation Laboratory, 1954.
2. Aron, W. A., "The Passage of Charged Particles Through Matter," (Thesis), University of California Radiation Laboratory Document, UCRL-1325, 1954.
3. Barkas, W., and M. Berger, "Tables of Energy Losses and Ranges of Heavy Charged Particles," SP-3013, NASA, 1964.
4. Bichsel, H., in American Institute of Physics Handbook, Second Edition, 8-21, 1963.
5. Sternheimer, R., "Range-Energy Relations for Protons in Be, C, Al, Cu, Pb, and Air," The Physical Review, 115, 137, 1959.
6. Aron, W., B. Hoffman, and F. Williams, "Range-Energy Curves," AECU-663, 1949 and supplement of 1951.
7. Brandt, W., "Energy Loss and Range of Charged Particles in Compounds," Dupont Research Report, July 1960.
8. Hill, C., W. Ritchie, K. Simpson, "Data Compilation and Evaluation of Space Shielding Problems, Range and Stopping Power Data," Lockheed Nuclear Products Report ER7777, Volume I, Lockheed Corporation, 1965.
9. Williamson, C., and J. Boujot, "Tables of Range and Rate of Energy Loss of Charged Particles of Energy of 0.5 to 150 Mev," CEA-2189, Centre d'Etudes Nucleaires, Sarclay, 1962.
10. Livingston, M., and H. A. Bethe, "Nuclear Dynamics, Experimental," Reviews of Modern Physics, 9, 245, 1937.
11. Fano, U., Preface to "Studies in Penetration of Charged Particles in Matter," Nuclear Science Series Report Number 39, 1964.
12. Fano, U., and J. Turner, "Contributions to the Theory of Shell Corrections," in Nuclear Science Series Report Number 39, 1964.
13. Jankus, V., "Radiative Correction for the Collision Loss of Heavy Particles," The Physical Review, 90, 4, 1953.
14. Fermi, E., "The Ionization Loss of Energy in Gases and Condensed Materials," The Physical Review, 57, 485, 1940.
15. Halpern, O., and H. Hall, "The Ionization Loss of Energy of Fast Charged Particles in Gases and Condensed Bodies," The Physical Review, 73, 477, 1948.
16. Sternheimer, R., "The Density Effect for the Ionization Loss in Various Materials," The Physical Review, 88, 851, 1952.

REFERENCES (cont'd)

17. Sternheimer, R., "The Density Effect for the Ionization Loss in Various Materials," The Physical Review, 103, 511, 1956.
18. Neufeld, J., and W. Snyder, "Dependence of the Average Charge of an Ion on the Density of the Surrounding Medium," The Physical Review, 107, 96, 1957.
19. Bichsel, H., and C. Tschalaer, "Range Difference Measurements for Protons in C, Al, Sapphire, Si, Quartz, Ge and Ag," Bulletin of the American Physical Society, II, 10, 723, 1965.
20. Warshaw, S., "The Stopping Power for Protons in Several Metals," The Physical Review, 76, 1759, 1949.
21. Bichsel, H., "Higher Shell Corrections in Stopping Power," Technical Report Number 3, U.S.C. Linear Accelerator Group, 21 June 1961; and "A Critical Review of Experimental Stopping Power and Range Data" in Reference 132.
22. Dalgarno, A., "The Stopping Powers of Atoms," Proceedings of the Physical Society (London), A, 76, 422, 1960.
23. Martin, F. W., and L. C. Northcliffe, "Energy Loss and Effective Charge of He, C, and Ar Ions below 10 Mev/amu in Gases," The Physical Review, 128, 1166, 1962.
24. Zrelov, V. and G. Stoletov, "Range-Energy Relation for 660-Mev Protons," Soviet Physics, 36, 461, 1959.
25. Thompson, T., "Effect of Chemical Structure on Stopping Powers for High Energy Protons," (Thesis), UCRL-1910, University of California Radiation Laboratory, 1952.
26. Bichsel, H., and E. Uhling, "Multiple Scattering Correction for Proton Ranges and the Evaluation of the L-Shell Correction and I Value for Aluminum," The Physical Review, 119, 167, 1960.
27. Barkas, W. H., and S. von Friesen, "High-Velocity Range and Energy-Loss Measurements in Al, Cu, Pb, U and Emulsion," Nuovo Cimento, Suppl. 19, 41, 1961.
28. Bakker, C. J., and E. Segre, "Stopping Power and Energy Loss for Ion Pair Production for 340 Mev Protons," The Physical Review, 81, 489, 1951.
29. "Stopping Powers for Use with Cavity Chambers," National Bureau of Standards Handbook 79, 1 September 1961.
30. Burkig, V., and K. MacKenzie, "Stopping Power of Some Metallic Elements for 19.8-Mev Protons," The Physical Review, 106, 848, 1957.
31. Caldwell, D., "Range-Energy Relation and Masses of the New Particles," The Physical Review, 100, 1955.

## REFERENCES (cont'd)

32. Hubbard, E., and K. MacKenzie, "The Range of 18-Mev Protons in Aluminum," The Physical Review, 85, 107, 1952
33. Simmons, D., "The Range-Energy Relation for Protons in Aluminum," Proceedings of the Physical Society (London), A, 65, 454, 1952.
34. Turner, J. "Effects of Shell Corrections to Stopping Power in Theoretical Dose Studies," Oak Ridge National Laboratory Report ORNL-P-659, November 1964.
35. Mather, R., and E. Segre, "Range-Energy Relation for 340-Mev Protons," The Physical Review, 84, 191, 1951.
36. Bichsel, H., R. Mozley, and W. Aron, "Range of 6- to 18-Mev Protons in Be, Al, Cu, Ag, and Au," The Physical Review, 105, 1788, 1957.
37. Bloembergen, N., and P. van Heerden, "The Range and Straggling of Protons between 35 and 120 Mev," The Physical Review, 83, 561, 1951.
38. Bloch, F., "Bremsvermögen vor Atomen mit Mehreren Elektronen," Zeitschrift Für Physik, 81, 353, 1933.
39. Brandt, W., "Stopping Power and Valence States," The Physical Review, 104, 691, 1956; and "Energy Loss of Fast Charged Particles in LiH," The Physical Review, 111, 1042, 1958.
40. Brandt, W., "Survey of Stopping Power," Health Physics, 1, 11, 1958.
41. Green, D., J. Cooper, and J. Harris, "Stopping Cross Sections of Metals for Protons of Energies from 400 to 1000 Kev," The Physical Review, 98, 466, 1955.
42. Bader, M., R. Pixley, F. Mozer, and W. Whaling, "Stopping Cross Sections of Solids for Protons, 50 - 600 Kev," The Physical Review, 103, 32, 1956.
43. Hall, T., "Ratio of Cross Sections for Electron Capture and Electron Loss by Proton Beams in Metals," The Physical Review, 103, 32, 1956.
44. Kanner, H., "Electron Capture and Loss Cross Sections for Protons Passing Through Air," The Physical Review, 84, 1211, 1951.
45. Starodutsev, S., and A. Romanov, "The Passage of Charged Particles through Matter," AEC-TR-6468, 1965. Translation available from US Dept. of Commerce.
46. Sternheimer, R., "Interaction of Radiation with Matter," in Nuclear Physics, 5, 1961.
47. Cranshaw, T., "Ionization by Fast Particles," Progress in Nuclear Physics, 2, 271, 1952.
48. Taylor, A., "Range-Energy Relations," Reports on Progress in Physics, 15, 49, 1952.
49. Uehling, E., "Penetration of Heavy Charged Particles in Matter," Annual Review of Nuclear Science, 4, 315, 1954.

REFERENCES (cont'd)

50. "Penetration of Charged Particles in Matter," National Research Council Publication Number 752, National Academy of Sciences, E. Uehling, Ed., 1960.
51. Brown, R., and N. Jarmie, Los Alamos Scientific Laboratory Report, LA-2156, 1958.
52. Allison, S., and S. Warshaw, "Passage of Heavy Particles Through Matter," Reviews of Modern Physics, 25, 779, 1953.
53. Whaling, W., "The Energy Loss of Charged Particles in Matter," Encyclopedia of Physics, 34, 193, 1958.
54. Kahn, D., "The Energy Loss of Protons in Metallic Foils and Mica," The Physical Review, 90, 503, 1953.
55. Phillips, J., "The Energy Loss of Low Energy Protons in Some Gases," The Physical Review, 90, 532, 1953.
56. Reynolds, H., D. Dunbar, W. Wenzel, and W. Whaling, "The Stopping Cross Section of Gases for Protons, 30 - 600 Kev," The Physical Review, 92, 742, 1953.
57. Wilcox, H., "Experimental Determination of Rate of Energy Loss for Slow  $H_1$ ,  $H_2$ , He, and Li Nuclei in Au and Al," The Physical Review, 74, 1743, 1948.
58. Crenshaw, C., "The Loss of Energy of Hydrogen Ions in Traversing Gases," The Physical Review, 62, 54, 1942.
59. Madsen, C., and P. Venkateswarlu, "Proton Stopping Power of Solid Beryllium," The Physical Review, 74, 648, 1948.
60. Tunnecliffe, P., and A. Ward, "The Relative Ionization Produced by Low Energy Protons, Deuterons and Alpha-Particles in Various Gases," The Proceedings of the Physical Society, 65, 16, 1952.
61. Cook, C., E. Jones, Jr., and T. Jorgensen, Jr., "Range-Energy Relations of 10- to 250-Kev Protons and Helium Ions in Various Gases," The Physical Review, 91, 1417, 1953.
62. Farmer, B., and H. Eichsel, "Range-Energy Measurements for 2- to 5-Mev Protons in Ni and Ag," Bulletin of the American Physical Society, 5, 263, 1960.
63. Brolley, J., and F. Ribe, "Energy Loss by 8.86-Mev Deuterons and 4.43-Mev Protons," The Physical Review, 98, 1112, 1955.
64. Chilton, A., J. Cooper, and J. Harris, "The Stopping Power of Several Elements for Protons," The Physical Review, 93, 413, 1954.
65. Brown, L., "Asymptotic Expression for the Stopping Power of K-Electrons," The Physical Review, 79, 297, 1950.



REFERENCES (cont'd)

66. Walske, M., "Stopping Power of K-Electrons," The Physical Review, 88, 1283, 1952.
67. Walske, M., "Stopping Power of L-Electrons," The Physical Review, 101, 940, 1956.
68. Khandelwal, G., and E. Merzbacher, "Stopping Power of M-Electrons," The Physical Review, 144, 349, 1966.
69. Khandelwal, G., Private Communication dated June 20, 1966.
70. Brandt, W., "Tight-Binding Corrections of Stopping Powers," The Physical Review, 112, 1624; 1958.
71. Peele, R., "Rapid Computation of Specific Energy Losses for Energetic Charged Particles," ORNL-TM-977, 29 April 1965.
72. Slater, J., "Atomic Shielding Constants," The Physical Review, 36, 57, 1930.
73. Janni, J., "Bethe Equation Shell Corrections for Elements Having Atomic Numbers between 5 and 92," Air Force Weapons Laboratory Report AFWL-TR-65-168, 1965.
74. Sandström, A., "Experimental Methods of X-Ray Spectroscopy," Vol. XXX, Encyclopedia of Physics, 226, 1957.
75. Hill, R., E. Church, and J. Mihelich, "The Determination of Gamma-Ray Energies from Beta-Ray Spectroscopy and a Table of Critical X-Ray Absorption Energies," The Review of Scientific Instruments, 23, 523, 1952.
76. Strominger, D., J. Hollander, and G. Seaborg, "Table of Isotopes," Reviews of Modern Physics, 30, #2, 585, 1958.
77. Fahrman, A., K. Hamrin, C. Nordberg, and K. Siegbahn, "Revision of Electron Binding Energies in Light Elements," The Physical Review Letters, 14, #5, 127, 1965.
78. Landau, L., Journal of Physics (USSR), 8, 201, 1944.
79. Sternheimer, R., "Range Straggling of Charged Particles in Be, C, Al, Cu, Pb, and Air," The Physical Review, 117, 485, 1959.
80. Barkas, W., F. Smith, and W. Birnbaum, "Range Straggling in Nuclear Track Emulsion," The Physical Review, 98, 605, 1955.
81. Fano, U., "Degradation and Range Straggling of High-Energy Radiations," The Physical Review, 92, 328, 1953.
82. Berger, M., "Multiple Scattering of Fast Protons in Photographic Emulsion," The Physical Review, 88, 59, 1952.
83. Berger, M., and S. Seltzer, "Multiple-Scattering Corrections for Proton Range Measurements," Nuclear Science Series Report Number 39, 1964.

REFERENCES (cont'd)

84. Bethe, H., "Molière's Theory of Multiple Scattering," The Physical Review, 89, 1256, 1953.
85. Bethe, H., and J. Ashkin, "Passage of Radiations through Matter," in Experimental Nuclear Physics, Volume I, 166, 1953.
86. Bethe, H., and J. Ashkin, "Passage of Radiations through Matter," in Experimental Nuclear Physics, E. Segre (editor), Vol I, 245, 1953.
87. Lewis, H., "Range Straggling of a Nonrelativistic Charged Particle," The Physical Review, 85, 20, 1952.
88. Lewis, H., "Multiple Scattering in an Infinite Medium," The Physical Review, 78, 526, 1950.
89. Scott, W., "Mean-Value Calculations for Projected Multiple Scattering," The Physical Review, 85, 245, 1952.
90. Scott, W., "Summary Calculations of Multiple Scattering," NBS Circular 527, 1954.
91. Scott, W., "The Theory of Small-Angle Multiple Scattering of Fast Charged Particles," Reviews of Modern Physics, 35, 231, 1963.
92. Scott, W., and H. Snyder, "On Scattering Induced Curvature for Fast Charged Particles," The Physical Review, 78, 223, 1950.
93. Snyder, H., and W. Scott, "Multiple Scattering of Fast Charged Particles," The Physical Review, 76, 220, 1949.
94. Blanchard, C., "Diffusion of Electrons in Infinite Media," NBS Circular 527, 1954.
95. Fano, U., "Inelastic Collisions and the Molière Theory of Multiple Scattering," The Physical Review, 93, 117, 1954.
96. Goldschmidt-Clermont, Y., "On the Measurement of Scattering in the Photographic Plate," Nuovo Cimento, 7, 331, 1950.
97. Spencer, L., "Theory of Electron Penetration," The Physical Review, 98, 1597, 1955.
98. Groetzinger, G., M. Berger, and F. Ribe, "Study of the Multiple Scattering of Fast Charged Particles in a Gas and Its Role in the Interpretation of Cloud-Chamber Tracks," The Physical Review, 77, 584, 1950.
99. Annis, M., H. Bridge, and S. Olbert, "Application of the Multiple Scattering Theory to Cloud-Chamber Measurements, II," The Physical Review, 89, 1216, 1953.
100. Goudsmit, S., and J. Saunderson, "Multiple Scattering of Electrons," The Physical Review, 57, 24, 1940.
101. Goudsmit, S., and J. Saunderson, "Multiple Scattering of Electrons, II," The Physical Review, 58, 36, 1940.

REFERENCES (cont'd)

102. Berger, M. "Monte Carlo Calculation of the Penetration and Diffusion of Fast Charged Particles," in Methods in Computational Physics, 1, 135, 1963.
103. McKinley, W., and H. Feshbach, "The Coulomb Scattering of Relativistic Electrons by Nuclei," The Physical Review, 74, 1759, 1948.
104. Nigam, B., M. Sundaresan, and Ta-You Wu, "Theory of Multiple Scattering; Second Born Approximation and Corrections to Molière's Work," The Physical Review, 115, 491, 1959.
105. Nigam, B., and V. Mathur, "Difference in the Multiple Scattering of Electrons and Positrons," The Physical Review, 121, 1577, 1961.
106. Molière, G., Zeitschrift für Naturforschung, 2A, 133, 1947.
107. Mott, N., and H. Massey, Theory of Atomic Collisions, New York, Oxford University Press, Second Edition, 1949.
108. Berger, M., and S. Seltzer, "Multiple Scattering Corrections for Proton Range Measurements," in Nuclear Science Series Report Number 39, 1964.
109. Seltzer, S., and M. Berger, "Energy Loss Straggling of Protons and Mesons: Tabulation of the Vavilov Distribution," in Nuclear Science Series Report Number 39, 1964.
110. Gooding, T., and R. Eisberg, "Statistical Fluctuations in Energy Losses of 37-Mev Protons," The Physical Review, 105, 357, 1957.
111. Bichsel, H., "Relative Ionization of Protons Near the End of Their Range," The Physical Review, 120, 1012, 1960.
112. Madsen, C., and P. Venkateswarlu, "Energy Straggling of Protons," The Physical Review, 74, 1782, 1948.
113. Shapiro, M., "Cross Sections for the Formation of the Compound Nucleus by Charged Particles," The Physical Review, 90, 171, 1953.
114. Pollock, E., and G. Schrank, "Proton Total Reaction Cross Sections at 16.4 Mev," The Physical Review, 140, B575, 1965.
115. Bertini, H., "Description of Printed Output from Intranuclear Cascade Calculation," ORNL-3433, 14 May 1963.
116. Bertini, H., "Monte Carlo Calculations on Intranuclear Cascades," ORNL-3383, 16 May 1963.
117. Metropolis, N., R. Bivins, M. Storm, A. Turkevich, J. Miller, and G. Friedlander, "Monte Carlo Calculations on Intranuclear Cascades; I, Low-Energy Studies," The Physical Review, 110, 185, 1958.
118. Metropolis, N., R. Bivins, M. Storm, J. Miller, G. Friedlander, and A. Turkevich, "Monte Carlo Calculations on Intranuclear Cascades; II, High-Energy Studies and Pion Processes," The Physical Review, 110, 204, 1958.

REFERENCES (cont'd)

119. Lindenbaum, S., "Collisions of  $<1$  Bev Particles (Excluding Electrons and Photons) with Nuclei," in Annual Review of Nuclear Science, 7, 317, 1957.
120. Cohen, F., and J. DuMond, "Our Knowledge of the Fundamental Constants of Physics and Chemistry in 1965," Reviews of Modern Physics, 37, 637, 1965.
121. Table of Atomic Weights, in Handbook of Chemistry and Physics, The Chemical Rubber Publishing Company, 44th Edition, 1962-1963.
122. Bichsel, H., "Experimental Range of Protons in Al," The Physical Review, 112, 1039, 1958.
123. Parkinson, D., R. Herb, J. Bellamy, and C. Hudson, "The Range of Protons in Aluminum and in Air," The Physical Review, 52, 75, 1937.
124. Sonett, C., and K. MacKenzie, "Relative Stopping Power of Various Metals for 20 Mev Protons," The Physical Review, 100, 734, 1955.
125. Nakano, G., K. MacKenzie, and H. Bichsel, "Relative Stopping Power of Some Metallic Elements for 28.7 Mev Protons," The Physical Review, 132, 291, 1963.
126. Haworth, L., and L. King, "The Stopping Power of Lithium for Low Energy Protons," The Physical Review, 54, 48, 1938.
127. Barkas, W., "The Range-Energy Relation in Emulsion, Part ii - The Theoretical Range," Nuovo Cimento, 8, #2, 201, 1958.
128. Goldwasser, E., F. Molls, and T. Robillard, "Direct Measurement of the Effect of Polarization on Energy Loss," The Physical Review, 93, 1763, 1955.
129. Rybakov, B., "Ranges of Protons in Medium and Heavy Elements," JETP, 1, 435, 1955 (as interpreted by Barkas and Berger in Ref. 3).
130. Nielsen, L., "Energy Loss and Straggling of Protons and Deuterons," Kongelige Danske Videnskabernes Selskab, Matematisk-Fysiske Meddelelser, 33, No. 6, 1961.
131. Nielsen, L., quoted by Bichsel, H., in the first appendix to "Higher Shell Corrections in Stopping Power," Technical Report Number 3, U.S.C. Linear Accelerator Group, 21 June 1962.
132. "Studies in Penetration of Charged Particles in Matter," Nuclear Science Series Report Number 39, 1964.
133. Heckman, H., B. Perkins, W. Simon, F. Smich, and W. Barkas, "Ranges and Energy-Loss Processes of Heavy Ions in Emulsion," The Physical Review, 182, 544, 1960.
134. Lattes, C., P. Fowler, and P. Cser, "A Study of the Nuclear Transmutations of Light Elements by the Photographic Method," Proceedings of the Physical Society, 59, 883, 1947.

REFERENCES (cont'd)

135. Rotblatt, J., "Range-Energy Relation for Protons and Alpha-Particles in Photographic Emulsions for Nuclear Research," Nature, 167, 550, 1951.
136. Garcia, J., "Radiative Corrections of Atoms and Molecules," The Physical Review, 147, 66, 1966.
137. Sachs, D., and J. Richardson, "The Absolute Energy Loss of 18-Mev Protons in Various Materials," The Physical Review, 83, 834, 1951.
138. Sachs, D., and J. Richardson, "Mean Excitation Potentials," The Physical Review, 89, 1163, 1953.
139. Bogaardt, M., and B Koudijs, "Sur les Potentiels Moyens D'Excitation et les Relations Energie-Parcours dans les Elements Legers," Physica, 18, 249, 1952.
140. Vasilevskiy, I., and Y. Prakoshkin, "Ionization Potentials of Atoms," Dubna, OIYaI (Joint Institute for Nuclear Research), 1961.
141. Friedlander, M., D. Keefl, and M. Menon, "The Range in G-5 Nuclear Emulsion for Protons with 87, 118, and 146 Mev," Nuovo Cimento, 5, 461, 1957.

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13. ABSTRACT Theoretical calculations have been made of the mean energy loss, pathlength, range, multiple scattering, and pathlength straggling of protons in 74 materials, including materials regularly used in radiation shielding and dosimetry. Emphasis has been placed on obtaining accurate results, especially for heavy materials and protons of very low energy. Values of the energy loss between 0.1 and 1.0 Mev were obtained by smoothing and interpolating experimental information. Above 1.0 Mev, the Bethe equation with all the necessary shell corrections has been used. The polarization effect has been calculated in detail for each material. Ranges have been obtained from the pathlengths by use of detailed multiple coulomb scattering theory. Comprehensive tabulations of the range straggling and multiple scattering have been presented for each of the materials. The energy loss and range calculations have been compared with the available experimental data and the mean deviation is usually within 1.0 percent. Deviation rarely exceeds the estimated error of the experimental data. The theoretical approach is also discussed in detail, and the method used to obtain the K, L, M, N, and O shell corrections is presented. A first-order correction has been made which compensates for the molecular binding effects occurring in compounds. The probability that a proton will undergo an inelastic nuclear interaction throughout its entire pathlength is also tabulated.		

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